IMPERIAL AGRICULTURAL
RESEARCH INSTITUTE, NEW DELHI.

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## LA REVUE A GRO IQUE CANADIENNE

VOLUME XIV

*September 1933 - August 1934*

PUBLISHED BY THE
CANADIAN SOCIETY OF TECHNICAL AGRICULTURISTS AT
OTTAWA, CANADA

*Assisted by the National Research Council, the Dominion Department of Agriculture, Macdonald College, Ontario Agricultural College, and the Provincial Departments of Agriculture in Ontario and Quebec*

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SCIENTIFIC AGRICULTURE

Vol. XIV SEPTEMBER, 1933 No. 1

# THE FUTURE OF AGRICULTURAL SCIENCE[1]

Sir A. Daniel Hall[2]

Mr. President and gentlemen:

I owe you an apology for attempting in an informal talk to assume the position of a reviewer of the way agricultural science is being pursued at the present time. I would like to begin by asking you to bear in mind the enormous increase in the specialization of science. I recall, for example, that it is almost exactly fifty years since I was taking my final examinations at Oxford in chemistry. And at that time students who were taking the Honour School of chemistry at Oxford were expected to be acquainted with the whole of that science, and to have read it right up to current research. We were expected to be able to answer questions about investigations that had been published say within a year of taking our examination. That was only fifty years ago. There was indeed a differentiation between organic and inorganic chemistry; but the more modern differentiations of physical chemistry, bio-chemistry, colloid chemistry, electro-chemistry, etc, were entirely unthought of. Then, as I say, one man was supposed to be able to cover the whole subject. At the present time, of course, no man pretends to know the whole of physical chemistry, still less the whole of chemistry, even if he is spending his life at it and is not merely an undergraduate undergoing his final examination.

I think the same thing holds true very much with regard to the progress and the methods of agricultural research. Looking back I realise that the formal organization of agricultural research in England has taken place during my life time, although research existed, of course, long before my time. The Experimental Station at Rothamsted began nearly a century ago but it was then a private institution, receiving no assistance from the State. It did in fact represent with one or two minor exceptions, the whole of the agricultural research that was then going on in Great Britain.

Somewhere in the late eighties and more particularly in the nineties organized agricultural research got a start in Great Britain, and when I look back upon my colleagues of that time who were recruited from the various fields of science to begin the new work, I see a very different type of man from the current research worker, for in those days a man was supposed to be able to cover the whole field of agriculture and the sciences depending upon it. I can best give you an example by recalling to you the late Professor T. B. Wood, whom many of you knew. For many years he was Director of, and indeed the creator of, that great school of agricultural science at Cambridge. Now T. B. Wood was indeed the all-round man of science in connection with agriculture. He was a farmer in the first instance, born and bred upon the farm. He went on farming himself; during the whole of his Cambridge career he was running a farm of his own, farming, as he was always proud to say, out of his own cheque book and not with the resources of some institution behind him, and therefore having to make it pay—and indeed he did make it pay. Besides that he was the head of the Institute of Research in Animal Nutrition at Cambridge. And he *was* the head of it, that is to say he was the originator of the methods of work, and he was controlling and directing research in that particular field. He, of course, was head of the School of Agriculture and as such was responsible for the general oversight of the institutions that dealt with animal diseases and plant breeding at Cambridge. He had papers to his credit on such divers subjects as the composition of mangolds, the colloids of wheat flour, Mendelian inheritance in sheep, and probable error in experimental plots. Well now, we are not likely again to see men of that type, who have this immense all-round acquaintance with all the development of science in connection with agriculture. They were men like the Greek, Milo of Crete, who by practicing with a calf gradually grew up to be able to carry a bull. Now-a-days the investigator is confronted with a full grown bull, and can not begin to learn to carry it.

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[1] An address delivered at the Thirteenth Annual Convention of the Canadian Society of Technical Agriculturists, Regina College, Regina, Saskatchewan, July 24, 1933.

[2] Director, John Innis Horticultural Institute, London, England.

Specialization, then, is a fact to be faced. We recognize the enormous power of the specialist, his way of penetrating into the mysteries; and in agriculture we are concerned with that most mysterious of all things, life. Yet we have to guard against some of the dangers to which our research is exposed. The danger arises, perhaps, from the interest of the subject itself. If you get a man working intimately, closely, with some problem of soil or of disease, he becomes so fascinated in the pursuit of knowledge that the end to which his researches are directed becomes forgotten in the interests of the problem itself. The means, as it were, become far more important than the end. This is almost inevitably so; and, of course, some of these problems as in soil physics or some of the elusive problems of mycology or of genetics lead on and on with no prospect of finality, so that the investigator settles down, as it were, for life. He will have colleagues in other countries similarly carried away by this intense specialization until in the end a sort of bridge party is made up. A worker in the United States "leads"; somebody in Jugo-Slavia plays the next card; there is a third person in England, perhaps, who joins in; and then you have a fourth from Holland or Sweden to play. These people all exchange papers with one another. They all feel very important and are entirely interested, but wholly indifferent to those outside the party. I had an instance in my laboratory not long ago, when one of my colleagues had prepared a paper. I toiled over this paper trying to get it as I thought intelligible—at any rate intelligible to myself—day after day; and about the tenth day, after talking it over I said, "Look here, you must begin again and write this all over; it is not really intelligible." And the lady—it was a lady in this case—turned to me and said, "What does it matter, there are only five people in the world who will read it and they will understand it." Well, that is the sort of game that our science may so easily become.

This high specialization exists; it is inevitable; and we can't get the best work done, and we can't solve or even get an appreciation of many of the difficult problems that are before us unless we have such specialists each at liberty to go on working in his own way, and pursuing his particular bent to the utmost. But can we do something to make these people human? In order to do that let us try to ensure that they have contacts with agriculture itself. In my own particular field at the present time I am concerned with genetics and plant breeding. But one has to try to make the young workers taking up genetics become interested in plants and in the actual growing of plants. They must not treat the plants that are being grown, perhaps by the thousands for their particular genetical study, as merely laboratory units but as living things, possessing other points of interest than crossings over in certain proportions or chromosomes in certain positions. What we have to try to ensure is that all our workers are making contacts with the practical man. We do this first of all to ensure that their work will have some immediate practical purpose; of course we must ever remember that the purest scientific work may suddenly bloom into something utilitarian. Just think, for example, of the number of men and of the length of time that was spent in the minute study of the nuclei of plants and animals, work which eventually defined the chromosomes and revealed the processes of mitosis and meiosis. For years and years that was abstract, pure science without the slightest thought that it was ever going to be of any practical value. Suddenly it blossomed, and in the hands of Morgan and his colleagues this study of the nucleus provided a physical basis for the Mendelian generalizations. So we obtained the whole material basis of the regulated breeding of plants and animals out of that bit of abstract, pure science. None the less I think we are more likely to get even our pure science work vital if we can persuade the workers to be agriculturists, horticulturists, and above all naturalists who have their eyes upon the living, growing organisms. It is peculiarly important in another way. Often it is only when you turn to the practical man who is working upon a very large scale with plants or animals that factors are disclosed, exceptions are thrown up, and difficulties are discovered which do provide a lead perhaps into the ocean of pure science itself; and, therefore, it is good from both the pure science point of view and the immediate needs of the practical man that all our research workers should have, as it were, their ears to the ground.

How can that be done? Well, as a working method, can we not allot to each of our workers in the laboratory together with his real fundamental problem that may require years of investigation, patience and the colaboration of many people, some proximate, short-term problem that arises from farm or garden itself? The one will give him his contacts and may suggest further long term problems; the other is, of course, his permanent fixed occupation. I think it is a reasonable way of going to work, to see that the abstract research worker has also a practical investigation which may bring some immediate help to the farmer or the gardener.

Now, may I pass on to consider briefly indeed what are the directions in which scientific research in regard to agriculture may probably be guided most profitably at the present time. I embark upon that question with a little more confidence in that we have recently set up in Great Britain an Agricultural Research Council, the opposite member to the Committees dealing with Scientific and Industrial Research, and with Medical Research in our country. It has been the duty of this Council to carry out a general review of the agricultural research that is in progress in Great Britain, and in so doing it has had almost necessarily to think a little about what is going on in the Empire and in other countries. While the review is by no means complete I think we begin to get the various subjects into a little perspective, and to see something of their relative importance. Perhaps the subject that has most been pressed upon us, the one which to most people seems to require the most strenuous effort, is the question of animal disease, or rather, as I should put it, the question of ensuring animal health. Many people do consider that the most pressing of all the problems before us.

Now I am bound to say, while reporting this as the general opinion, that I do not personally altogether agree, because I am looking at the problem from the point of view of health rather than of disease. I see the task of the people who are dealing with the health side of animals to be in future very much more hygiene and the maintenance of health than the cure of disease. What I would like to see is a class of veterinarians who are officers of animal health rather than practitioners. There must always be practitioners who are concerned with surgical cases and with specific illnesses of valuable animals, but it seems to me that the great efforts of the profession should be rather of a public nature. Instead of being called in to this ailing cow, or that fretting horse, we want to see a class of men who have charge of a district, who are thinking about the horses, the cattle, the sheep and the pigs and how to keep disease away from them. Naturally, they will have to know about the endemic diseases, but breeding, environment, nutrition, and other factors in hygiene will be equally important. I think that is going to be the direction in which the veterinary profession itself will eventually move, and that the veterinarian of the future will be the kind of public officer who is taking prophylactic and preventive measures and who is studying problems like nutrition and so forth, so as to ensure a greater amount of health amongst the animal population. You see it is only latterly that we have really begun to appreciate what an enormous factor nutrition is in the health of livestock; we don't even yet know all that is necessary.

From another point of view I think we shall really have to attack these problems of animal disease and their occurrence from the genetic standpoint. We know of course already, in dealing with plants, how a great number of diseases can effectively be dealt with by breeding immune races. We have succeeded in breeding races of potatoes which are immune from corky scab, or the wart disease as we call it at home, a disease which a few years ago threatened to wipe out potato growing in many districts of Great Britain. In all kinds of directions we can see how the most profitable and certain attack upon diseases in plants is to breed a race that is immune. We can't dispense with measures of spraying at the present time because it takes time to breed immune varieties, first to find immunity, and then to breed from it. And when you are dealing with fruit—well a generation of apples in our country means seven years, and so the research worker isn't going to get very many generations in his own lifetime. But still this line of attack has been so profitably pursued in many directions that one can be reasonably sure that in the end our real method of dealing with disease in plants is going to be from the genetic side. I think the same method will come amongst animals. There are cases—you can quote instances—which show you that certain kinds of immunity are inherited through characters subject to the laws of inheritance that have been worked out for other characters. If then we are given time and space and numbers, I think we can do much to create races which will be immune to many of the diseases that cause such large monetary losses at the present time.

That leads me on to consider another very big problem before us. Many of our economic problems in dealing with animals, besides this one of disease, can be solved if we can only set to work at the breeding of animals with the same intensity and on a scale comparable with the methods that we have employed with plants. It is going to be a difficult matter because of the complications due to sex, difficult also because so many of the characters of animals are governed by environmental conditions as well as by genetic make-up. We shall have to deal with large numbers of animals and that means expense. Such work again becomes difficult because we have to fight to a certain extent against the inherited traditions of the farming community. I say we have to fight against the inherited traditions because we do come up against the devotion of the best farmers to their conception of pedigree. If you are going to set to work and breed say a new type of sheep that shall combine a great many advantages that are scattered about amongst the different breeds of sheep at the present time, you at once are opposed both by the vested interests in existing breeds and by that instinctive, persistent, long-inherited tradition of the farmer that pedigree is a thing to look to for its own sake. Pedigree was a great step in its day, and the principles that were laid down by the earliest breeders of animals have done marvellous things in improving livestock. But, as you all know, pedigree that is founded simply upon records of breeding and upon show performance is not really sufficient. I have been interested to notice how much progress you are making in Canada in working out performance records and new types of pedigree for many classes of livestock that will, for instance in regard to milch cows, show records of performance in the past; records of the performance not only of the dam, but records of performance of the bull showing his ability to get better milk-producing stock. We are tentatively beginning to recognize performance records of that kind with regard to the breeding of pigs. We don't simply want to know that the boar is of such a line and won such and such a prize at various shows; we want to know the record of the litters he got, and how steadily he carried with him a commercial degree of prolificacy. And for all the animals that we have to deal with we need this new conception of pedigree, which shall be based upon performance and which shall be an assurance of performance in the future.

But I want to go further than that and to begin recreating. I do deliberately say that the time has come when our knowledge of the laws of inheritance that have been worked out in connection with the smaller animals at the present time has become sufficient to enable us to step forward and create new breeds. I call them synthetic breeds, because I want to put together within our new breeds many of the excellent characteristics that are at the present time confined, perhaps, to one or two breeds only. It certainly can be done. The only question is whether any of us will have the courage to set to work upon a scale, and to face up to the financial expense, that such breeding will involve during the early stages.

One can begin to see that not only the time is ripe for such work from the scientific point of view in that we are beginning to have sufficient knowledge of how to breed for milk or wool, but perhaps we are getting to the stage when we can see from the economic point of view how it can be done. After all are we not in Great Britain just beginning to feel out towards—I won't say simply co-operation in agriculture—but towards a planned agriculture. A planned agriculture will involve a certain amount of direction and control of methods—I won't say of the actual work—of the farm. At the present time when contributions for research are being cut down it would not be much good asking for a farm of adequate size, and say 20,000 head of cattle to begin a new breed. But if there is central market control it ought not to be so difficult to ensure the co-operation of we will say 200 farmers, each with a certain number of cattle, towards such a common objective, that the cattle are all to be bred under direction, generation after generation towards a new synthesis, a new type of breed. It is quite true that at first you would be producing a set of mongrels, but then the loss to each individual through the mongrels would never be great and would disappear as the new breed emerged. I believe that some such organization will make it possible to ensure a genetic improvement in our existing breeds of livestock.

I am bound to tell you that when I have thrown this idea out in public in Great Britain it has been received in the coldest fashion by any farmer who happens to hear it.

Well now, on this occasion, talking in an informal way, you won't want to hear me say anything about the problems of genetics in plants, particularly the problems of disease and that most insidious class of diseases lumped together as virus diseases. Sometime there will be another occasion on which I may be able to deal with these questions. Nor again do I think this the occasion to discuss many of the new lines of thought that have been pointed out for us in considering problems of the soil.

If there is one other line of research which one really would like to say something about, it is the field that is opening up with regard to the minute physiology of plants. One of the difficulties in dealing with plant physiology in the past has been the purely technical one of analysis. New methods of micro-analysis are being worked out to an extraordinary degree, and appliances are being put at the disposal of the research worker engaged with the intimate physiology of plants that are altogether outside our conception of even twenty years ago. It was only the other day when I was in Pasadena that I was shown the methods by which micro-analysis of the chromosomes is being attacked at the present time. It is now possible to identify certain mineral elements in particular chromosomes of a plant. Well, that is pushing refined analysis to an extreme; and, as I say, in the light of these methods and some of the results that have already accrued, I believe this is going to be one of the most fertile lines of attack that remains open before us. It is an extraordinarily difficult method to follow, but one which will have a bearing upon our practical problems of plant growth in many and diverse directions.

But however much we look over the field of agricultural science and research work in connection with it, we are sooner or later up against the big economic problem. What is the good of all our science, and what is the good of all our research, if the fundamental basis of agriculture as a means of enabling men to live by tilling the soil and raising animals is wrong; if the farmer can't get a living, and if the improvements that we can promise from our science weigh so little that they can not overcome these fundamental economic problems? This point of view is something that those of us who are dealing with research in agriculture can not afford to put out of our minds; that behind all our efforts, behind all the improvements that we may suggest, behind the transformations that we can make in our farming, we have to consider the ultimate transformation of the farming individual. Yours is almost single-man farming, ours a little more organized into small capitalist units; how are such men to be fitted into the organization that modern thought, modern science, modern improvements seem to demand? The demand is insistent—the human mind once having got upon this efficiency track will go on pursuing it. The agricultural problem is how to ensure this type of efficiency while at the same time not effecting utter social disorganization by entirely knocking out the individual peasant farmer. At present the competition between the peasant and the great organization is still perhaps a little doubtful. I don't think the case for the big organized scientific farm has yet been proved up to the hilt.

It was only the other day I was being taken over one of these big organized ranches in Southern California, something like 6500 acres chiefly under fruit crops of one kind or another, all managed with the sort of efficiency and organization that we normally associate with the factory. The control of labour and materials, the organization of transport and marketing, all seemed to me just about as good as you possibly could get as far as I could see from a casual inspection, and some examination of the books and records. And yet, with all that, the people who are running the show confessed to me that they didn't know whether they were really going to succeed or not, as compared with the little individual man who had his four or five acres of oranges or of apricots, and did all the work himself.

The utmost advantages, as I say, of organization and science, and wealth and capital and so on—big business *in excelso*—were still fighting a not certainly victorious battle against the family farmer who is willing to put in his twelve or sixteen hours a day on his own little potato patch. Well, I can't but think in the end that the big man with this form of organization is going to win out. Up to the present time the individual has kept his end up by working twelve hours a day, and by indenting upon the time of his wife and his children. In many countries he shows that he is getting rather tired of the job and prefers to earn wages at the factory that has sprung up nearby; or at any rate if he sticks it out his children are not disposed to carry on in quite the same way. We can see in the Old World the disintegration of the peasant system under the attractions of industry and the pressure on prices started by the big organized farm, which in many quarters has progressed far enough to have made the living of the peasant very precarious.

Well, as I say, that is the ultimate problem that is before us. We are all aiming at efficiency, the more efficient production of plant food from the soil, and the more efficient conversion of that same plant food into animal food. Every time we have one of these revivals in efficiency—and revivals have been effected within our time—there is a renewed attack upon what is after all the mainstay of farming all over the world, the individual, single-man, peasant cultivator. I think it is up to us to have that problem always before us, and see that economic investigations go hand in hand with our scientific investigations. The one great objective in these economic investigations ought to be to see how far it is possible to organize these individuals who are at present weak, scattered units, to organize them so they can take their part in one of these big efficient organizations and yet remain still independent human beings, inheriting the value of their own initiative and hard work.

# THE RELATION OF INSECT ACTIVITIES TO FOREST DEVELOPMENT AS EXEMPLIFIED IN THE FORESTS OF EASTERN NORTH AMERICA[1]

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[Received for publication May 11, 1933]

## HISTORY OF THE FOREST

*The Primeval Forest.* Some three centuries ago, when the French and English settlers were building cabins along the north Atlantic coast, the eastern part of North America was covered by a vast and almost unbroken forest. It extended from the prairies to the sea and from the south Atlantic coast to Hudson's Bay. It comprised hardwoods of many species with conifers on the uplands in the south and conifers with fewer species of hardwoods in the north. From the tales that have come down to us and the story revealed in the forest itself we can guess at its composition. White and red pine, usually mixed with balsam fir, spruce, and hardwoods extended over an enormous area in the New England and North Atlantic states, in the provinces of Nova Scotia and New Brunswick, and in the southern portions of Quebec and Ontario. White spruce, with red spruce in the far East, usually mixed with balsam fir and often with hardwoods, occupied parts of the same area, forming dense stands on the higher ground in Maine and Southern Canada and stretching in scattered forests into the extreme north beyond the Arctic Circle. Balsam fir occurred largely in mixed forests but also in pure stands on considerable areas of the higher slopes. Jack pine grew then, as at the present time, on sandy plains and ridges, but there is probably much more of it now than there was in the primeval forest. Larch or tamarac covered swampy areas throughout the entire region and although it did not occur in extensive forests its total quantity must have been enormous. Hemlock occurred mainly in mixed stands from Southern Ontario and Southern Quebec southward. Black spruce, then as now, grew in bogs and wet places and in addition, covered a vast belt of territory stretching across the area now known as Northern Ontario and Northern Quebec. Cedar grew in large quantity on moist ground about the margins of lakes and streams. The hardwoods were more abundant in quantity and more numerous in species in the southern half of the territory; they occurred in considerable quantities, nevertheless, northward throughout the Maritime Provinces and in the southern parts of Quebec and Ontario, but only the white birch and poplars extended beyond the black spruce belt into the extreme north.

In this ancient forest there were undoubtedly many changes from time to time. Fires set by Indians or caused by lightning no doubt swept off the mature timber on areas of considerable size with a resultant change in forest types. Insect pests, such as the spruce budworm and the hemlock looper, probably ravaged portions of the forest then, as they have done in later years over larger areas, and again changes in forest types must have been the result. In the mixed forests of pine, hardwoods, spruce and balsam, there was probably a rotation of dominant species. In the great black spruce areas of Northern Quebec and Northern Ontario, on the other hand, the conditions were probably much more stable; it is likely that a large part of that country has been covered with black spruce for many centuries and would continue so, unless interfered with by man, throughout this geologic age.

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[1] Annual address given before the Entomological Society of America at the twenty-seventh annual meeting at Atlantic City, N.J., U.S.A., December 28, 1932.
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When the white man reached these shores, nevertheless, he entered a forest which in spite of certain periodic or fortuitous changes, probably had acquired a considerable degree of equilibrium and could have maintained indefinitely its general characteristics. The development of the white man's civilization has resulted in the demolition of the forest on an enormous extent of its original area and has produced directly or indirectly an extensive deterioration in the remaining timber over almost all the territory south of the black spruce belt in Northern Quebec.

*The Present Forest.* The result of these changes may be summarized in a few words. The original virgin forest of red and white pine has virtually disappeared. There are, so far as I know, only three considerable areas of virgin white and red pine left, one in the upper drainage basin of the Ottawa River in Western Quebec, one in the Quetico district of Western Ontario and one in the Missisaga region of Algoma in Ontario. When the white and red pine were cut, they were usually replaced by spruce, balsam fir and hardwoods, with the result that the areas on which the young stands of these pines are now growing are only a minute fraction of the original pine forest.

The original stands of nearly pure white spruce have almost disappeared, except in the northern and less accessible valleys; but there is still a considerable quantity of virgin white spruce in mixed forests which was left when the pine was cut, and which is now being utilized. The finest virgin stand of white spruce remaining in the East is to be found in the alpine valleys of the Gaspé peninsula in the province of Quebec.

Cuttings and insect epidemics in mixed spruce-balsam forests have frequently been followed by dense crops of balsam fir, with the result that on these areas the percentage of spruce has been greatly reduced while at the same time the balsam fir has increased in volume on an enormous extent of country, and it has replaced to a large degree the more valuable pine and spruce. Examples of the primeval balsam forest still remain in the higher or less accessible areas; one of the finest is to be found on an upland plateau in the extreme north of Cape Breton Island. Hemlock was utilized extensively in the past for tan bark and the old trees are found now chiefly about pleasure resorts. A splendid stand of virgin hemlock still remains uncut in the centre of Nova Scotia, north of Lake Rossignal, a perfect fairy land of forest beauty. Larch virtually disappeared from our Eastern forests as a commercial tree many years ago, swept away by repeated attacks of the larch sawfly. Today, a younger crop of larch is growing on an area that is possibly somewhat reduced in extent. The great black spruce belt across Northern Quebec and Northern Ontario still exists, although greatly reduced in area by lumbering, by extensive fires and by settlement along the transcontinental railway. Jack pine will always remain on sites of poorer soil and its total volume has been greatly increased in recent years as the result of numerous fires and lumbering. Cedar has been cut out to such a degree that very little is left of commercial size in the northern and northeastern sections.

The hardwoods have undergone many changes, but they cannot be described here in detail. The species with a present high commercial value have been greatly reduced in volume throughout the Canadian zone, while in the mixed forests of the same region birch and poplar have increased greatly in volume as a result of fires and lumbering.

The magnitude of changes on so vast a scale may be appreciated better by considering the history of the forest on a particular area. The Ottawa River drainage basin comprises an enormous extent of country all of which was originally covered with forest. The upper or western portion is still a forested country although the greater part of it has been cut over several times for lumber or pulpwood; the lower portion is an agricultural section, with many scattered towns and villages. Furthermore, the nature of the original forest and the history of the lumbering operations on the area are recorded with some degree of accuracy. The history of the forest in the Ottawa Valley, therefore, should illustrate fairly well the general situation.

The Ottawa River drains an area of 35,416,000 acres of which about 28,000,000 acres are, or were, productive forest land. The original stand of saw timber is estimated to have been at least 500 billion board feet (about 125 times the present annual cut in the whole of Canada). It is believed that at least one half of this timber (250 billion board feet) was white and red pine; 45% (225 billion feet) was spruce, balsam and other softwoods, and 5% (25 billion feet) was hardwood. The present stand is estimated to consist of not more than 10 billion feet of white and red pine, 5 billion feet of other softwoods, and 4 billion feet of hardwoods, a total of 19 billion board feet (*1*).

In addition, there are perhaps 40 million cords of softwood and 25 million cords of hardwood of smaller sizes suitable for pulpwood, ties, posts, fuel, etc., or the equivalent of a little over 50 billion board feet of all sizes. The records which are available indicate that during the last 120 years the amount cut for use has been between 35 and 40 billion board feet. The balance, some 410 billion feet, has been destroyed, chiefly by forest fires, land clearing, insects and fungi (*1*).

In effect, the forested area of the northeastern portion of North America has been reduced in extent to an enormous degree and the timber values have been largely dissipated on a great proportion of the forest land that remains. Instead of the big timber of the past, we have small trees, species of lesser value, thousands of miles of pure forest land on which repeated fires have exterminated all species of commercial importance, and, in general, a forest which is at best hardly holding its own against the agencies which are still operating to destroy it, and containing timber supplies which will probably be insufficient for the needs of the next generation.

Nevertheless, there is still a great quantity of commercial timber in Eastern North America and a large amount of young growth which, if protected, will be invaluable in the future. There is still a great forest, one that is well worth protecting, and one that will yield vast returns if it receives the care from this generation that it deserves.

## DESTRUCTIVE AGENCIES

The destruction of timber has resulted chiefly from five causes; the activities of the settler and lumberman, from fires, insects, fungi and from windstorms and heavy snow. The deterioration in the remaining forest has been occasioned through the change to less valuable timber species following fires, cutting, and insect outbreaks; through unhealthy conditions produced in the remaining stands by cutting, and through the effects of injury by insects and fungous diseases. In this connection, it should be noted that many of the more destructive forest insects in the country have been imported from Europe through the agency of man, and the injury they have caused must be charged against man's activities.

*Insect activities.* In this reduction of the original forest, insect life has played a very prominent rôle, and one that has become increasingly important during recent times. It is, however, only one phase of forest insect activity. Insects which are considered "primary" enemies feed upon some part of the living tree and are potentially destructive. Most of the primary species cause little actual injury beyond an occasional severe pruning; some are notoriously destructive and periodically occur in great outbreaks, whilst other species, usually of little or no economic importance, suddenly appear in widespread infestations. A second great category of forest insects includes "secondary" enemies, since they attack only dying or dead trees or wood products. In so far as commercial values are concerned, some of these species cause a vast amount of loss—sawyer beetles and others in fire-killed timber and saw logs and in log buildings, for example, or powder post beetles in stored wood products. In so far as the health and wellbeing of the forest is concerned, however, the "secondary" species are of importance chiefly as scavangers and are either beneficial or neutral in their effect on forest development. It is probable that the activities of many secondary species are extremely beneficial to the forest in hastening the death of overmature and weakened trees and thus liberating the young growth and also in accelerating the destruction of the debris on the forest floor. It is obvious that the destruction of the debris is essential to the health and natural development of the forest, particularly in facilitating the growth of seedlings and in providing plant food and a moisture-retaining layer of duff over the forest floor.

The most impressive effect of insect activities in the forest is the destruction of timber wrought by great epidemics of the primary species. There might be recorded a long list of major pests which have contributed their considerable part towards the destruction of the primeval forest; but only a few of the most destructive species have been selected to serve as illustrations and they have been confined largely to those affecting coniferous trees.

*The Spruce Budworm* (*Cacoecia fumiferana* Clem.). Perhaps the most striking example of insect destruction in the forest is afforded by the great spruce budworm outbreak of the last generation, which extended eventually over an enormous territory including the state of Maine and all Eastern Canada from the Atlantic Ocean to Central Ontario south of the great black spruce belt. It did not spread down the North Shore of the Gulf of St. Lawrence, and for some unknown reason it missed the Gaspé peninsula; but it missed very little else in all that vast territory, where balsam fir was growing.

The ravages of the budworm during the last 20 years, in which such enormous quantities of timber were killed, probably constituted the most destructive forest insect outbreak that has ever been recorded. It has been estimated that in Eastern Canada alone more than 200 million cords of balsam and spruce were destroyed. The vast amount of this loss can be better appreciated by comparing it with the losses caused by fires. It has recently been estimated by one of our most competent foresters that fires have destroyed balsam and spruce in Eastern Canada during the last 20 years to the amount of approximately 70 million cords (*1*). The spruce budworm alone destroyed three times as much.

The adult insect is a small brownish moth which appears in July and lays its eggs on the needles of fir, spruce and hemlock. The caterpillars which hatch from the eggs go immediately into hibernation in minute silken cases on the twigs. In the following spring they appear when the balsam and white spruce buds are opening and feed upon the buds and young foliage, avoiding the old needles until the young twigs are destroyed. Balsam fir and red spruce are injured most severely, white spruce usually to a lesser degree, and black spruce is usually immune from very serious defoliation. After two or three years of severe injury, the older stands of balsam and red spruce begin to die and in the overmature stands the mortality may attain more than 90%. The younger and thrifty stands of balsam fir are usually able to survive without serious injury and on this fact the recommendations for control are based.

During the last generation, lumbering, fires and insect outbreaks have resulted in augmenting to an enormous degree the original quantities of balsam fir, and this tree will have a very prominent place in the pulpwood industry of the coming generations. In the forests of New Brunswick, for example, one effect of the spruce budworm outbreak was to increase the percentage of balsam fir from about 50% in the old stand which was killed to 85% in the young crop which is now growing up (*2*). If great areas of balsam fir are permitted to become overmature, another and even more destructive spruce budworm outbreak may eventually be expected. On the other hand, if the remaining overmature stands are utilized and the young balsam cut on a short rotation, the forest should become very largely immune to destructive budworm outbreaks.

*The Larch Sawfly* (*Lygaeonematus erichsoni* Hg.). The larch or tamarac sawfly is a most destructive enemy of the American larch. The larvae feed upon the foliage, which may be more or less completely destroyed, and they go into hibernation in silken cocoons on the ground beneath the trees. It is possibly a European insect which was brought into this country in some unknown way, probably more than 100 years ago. A reference to an insect defoliating larch, published by Audubon in 1835 and recording an outbreak which occurred 25 years before, may possibly refer to this insect (*3*). The species was apparently described from Massachusetts, under the name *Nematus notabilis* Cresson, in 1860, but it was not reported as a widely distributed and injurious insect until about 20 years later. In the years immediately following 1880, the sawfly developed into a tremendous outbreak extending throughout all Eastern Canada and the New England States from Nova Scotia and Maine to the Great Lakes. By 1890, nearly all the larch of commercial size in Eastern Canada had died as a result of this attack. More recently, the outbreak has spread westward past the Great Lakes and north of the prairies into British Columbia and the Yukon, so that the sawfly now covers almost the entire range of the eastern larch.

The young stands of larch which have grown since the original outbreak occurred are now approaching commercial size. The sawfly has been varyingly abundant on these young stands, but not to a destructive degree, and during the last few years its numbers have been greatly reduced. In the years 1911, 1912 and 1913, a European parasite of the larch sawfly (*Mesoleius tenthredinis* Morley) was imported into this country from Britain and distributed in several places in Eastern Canada and Manitoba. This parasite has become established and has recently been recovered as far as 200 miles from the place of liberation. An attempt has been made to spread the parasite more widely in Eastern Canada, but during the last 10 years there have been no larch sawfly outbreaks in Europe from which they could be obtained, and for the last two years there have been none in Eastern Canada.

How much the imported parasites have had to do with reducing the numbers of the sawfly cannot yet be determined. It is possible that native parasites may have recently become more effective.

*The Larch Case-bearer* (*Haploptilia laricella* Hb.). For the past three years another defoliating insect, also of European origin, known as the larch case bearer, has spread in a severe infestation on larch stands throughout the eastern forest from Nova Scotia and Maine to Central Ontario. The needles are mined and killed by the small caterpillars and the outbreak has been so intense that in 1932 apparently most of the larch from New Brunswick to Algonquin Park in Ontario was almost completely defoliated. After the foliage has been destroyed by the caterpillars a second crop of needles is produced, and on this account previous outbreaks have not proven to be destructive. The present outbreak by the case-bearer, however, is apparently the most severe that has ever been experienced in this country, and it hardly seems possible that the trees could long withstand such severe attacks uninjured.

*The Eastern Hemlock Looper* (*Ellopia fiscellaria* Guen.). In the years 1925 to 1928, defoliating caterpillars known as the eastern hemlock looper, destroyed a large amount of hemlock in Wisconsin, Minnesota and Central Ontario. In the Lake States the same species attacks balsam fir, and it has long been known as a destructive enemy of that tree on the island of Newfoundland. In Ontario, however, in so far as we know, the looper has confined its attacks to hemlock, and until recently this had apparently been the case in the province of Quebec. In the year 1928, extensive outbreaks on balsam occurred on the North Shore of the Gulf of St. Lawrence. The outbreaks lasted for three years and disappeared. More than 100 square miles were affected in three large river valleys.

In 1929, an airplane dusting operation was carried out on one infestation and the caterpillars were almost completely destroyed. The outbreak subsided in another valley in 1930 and in the third a year later. Cold wet weather in early summer apparently was effective in destroying great numbers of the young caterpillars in the last two outbreaks, and may have been the chief influence in reducing the outbreak in those districts.

*Bark-beetles*. An extraordinary amount of injury has been caused in North American forests, particularly in the West, by the small beetles known as bark-beetles. Although many species of these insects occur in eastern forests only a few are of primary importance. The chief of these is the eastern spruce bark-beetle (*Dendroctonus piceaperda* Hopk.) which is now causing extensive injury in the Gaspé peninsula of Quebec.

The brown or black beetles, one-third of an inch long, breed only in the bark of spruce, chiefly in white spruce and red spruce. The vertical egg-tunnels, four to six inches in length, are cut between the bark and the wood on the trunk of the tree. In living trees the flow of sap is quickly checked and the death of the tree results very rapidly. Under normal conditions in the forest this species breeds in weakened or dying trees, in windfalls and in logs; but when their numbers become very great they readily attack and kill healthy trees and they have in the past destroyed large quantities of the finest white and red spruce in the eastern forests. Their outbreaks appear to have a certain periodicity, and we are now experiencing a series of attacks by this species in the forests of Quebec and in the Maritime Provinces.

*The Balsam Woolly Aphis* (*Dreyfusia piceae* Rtzb.). A species of bark infesting aphis, known as the European balsam woolly aphis, was imported from Europe into Eastern North America many years ago. It has been found affecting balsam fir in the Maritime Provinces and in several places in the Eastern United States, but it has increased most abundantly in Nova Scotia, New Brunswick and Maine. It is now spreading northward through New Brunswick and will possibly become distributed eventually throughout the balsam forests of Eastern North America. The insect is a minute plant louse with the body covered by white, wool-like, wax threads; it lives on the bark of the trunk or twigs and sucks the sap through the long slender beak which penetrates deep into the bark. When the insects are abundant, wool-like patches appear on the trunks of balsam fir, the only tree on which it occurs. This species kills the trees directly, but the most serious effect of its feeding occurs on young stands in which it produces a malformed growth, called the balsam gout, that may completely ruin or even kill the trees. In European forests this species is not considered to be of major importance, and it is evident that the North American balsam (*Abies balsamea* (L.) Miller) reacts much more strongly to the insects' attack than do the European species, both in regard to the injury to the trunk and to the malformation of the young trees and growing tops. The form affecting the buds and twigs has been distinguished in Europe under the name *D. piceae* var. *Bouvieri* Chol., and its effect on exotic species of *Abies* is said to be more serious than it is on native European species.

Certain species of agromyzids are being brought from Britain for distribution in the Maritime outbreak.

*The European Spruce Sawfly.* In 1930, a large area of white spruce in the Gaspé peninsula was found to be affected by a defoliating sawfly larva which was subsequently determined to be *Diprion polytomum* Hartig, a native of central and southern Europe where it is of but little economic importance. It is assumed that the insect has been introduced into this country sometime during the past generation. Although so abundant in the Gaspé, this sawfly has never been recognized elsewhere in Eastern Canada, except that one specimen collected near Ottawa in 1932 is now believed to belong to this species. Several specimens were taken in Maine in 1931 and in 1932 and it was recorded from one other locality in the New England States in 1931.

Biological investigations, ground surveys and an aerial survey were carried out on the Gaspé outbreak in 1931. The infestation then covered the entire central area of the peninsula, with the severest degree of attack confined to the upland valleys of the interior. In 1932 the outbreak continued in severity in the central area and increased over a considerably extended range. In the most heavily infested valleys, the white spruce is now severely defoliated, with a noticeable retardation in growth extending over about four years. There is little doubt that much of the timber is badly weakened, although only a very few trees have yet been killed by the sawfly. There is every reason to expect that the outbreak will continue, although with less severity, in 1933, and the black spruce is now being attacked in some places as readily as is the white spruce. The larvae feed only on the old foliage, leaving the young twigs of the current year practically untouched, and this fact probably explains the ability of the trees to withstand the defoliation. The larvae hibernate in cocoons on the ground beneath the trees, and during the last two years considerably more than 50% of the cocoons have carried over the summer to the following year. This habit is of particular importance inasmuch as mice and shrews have thereby a continuous opportunity to feed upon the larvae. During the past two years these animals have destroyed more than 40% of the hibernating cocoons and they are at present the most important factor in control. Only a few parasitized larvae have been found. Males are practically unknown, a fact which is probably significant in connection with the rapid increase of the outbreak.

During the past summer an effort was made to obtain parasites of this species in Central Europe and a supply will be available for distribution in the Gaspé outbreak in the spring of 1933. Inasmuch as native parasites have not yet attacked the sawfly, the introduction of the original parasites from Europe should prove to be beneficial; it is at all events the only forward step toward control that appears to be feasible at the moment. It has been determined that the sawfly succumbs readily to calcium arsenate and we have learned how to dust forests by airplane. When financial conditions become more favourable, airplane dusting may be employed to protect the most valuable stands.

*The Black-headed Budworm.* In the summer of 1929, a large area of balsam forest, some 200 square miles in extent, in the southern part of Cape Breton island was found to be heavily infested with caterpillars of the black-headed budworm (*Peronea variana* Fern.), a species with a method of feeding closely similar to that of the spruce budworm. The species had previously been exceedingly rare in Eastern Canada, only a few specimens having ever been collected. In 1930, some 500 square miles of territory were covered by this infestation; in 1931 the larvae were reduced to one-tenth of the number in 1930 and the infestation subsided at the end of the season; in 1932 it has practically disappeared.

*The European Beech Scale* (*Cryptococcus fagi* Barensp). The European beech scale is a minute sap sucking insect covered with wool-like wax threads. It feeds on the bark of beech, whose trunks become covered with wool-like patches of the insects when the latter are very abundant. When followed by certain bark infesting fungi (*Nectria*) this species is very destructive to the American beech. It was introduced into Nova Scotia many years ago and has since spread throughout all parts of that province and throughout the southern part of New Brunswick, causing a very heavy mortality in beech stands. It occurs also in the New England States, although not yet in Quebec or Ontario. It will probably kill a large proportion of the beech in parts of Eastern North America where the species of *Nectria* which can follow it happens to be present.

The examples that have been presented include a few of the most injurious and more interesting of the major pests of the eastern forests, but the list could be extended to include many species, some of which, like the white pine weevil, are perennial in their depredations, whilst others spring into importance only at long intervals as the cause of extensive infestations.

*Indirect Effects of Insect Injuries.* An important effect of insect outbreaks is the reduction in the growth and health of the affected timber. Even though little actual mortality be caused, an extensive infestation may result in an enormous unseen loss through the reduction of diameter and height growth in the timber as well as in an unthrifty condition of the stand. The present great outbreak of the larch case bearer can hardly fail to produce such an effect. Judging by investigations made in Maine, Connecticut and New Brunswick, the infestations of defoliating insects, *Bucculatrix canadensisella* Chamb., *Phyllotoma nemorata* Fallen, and *Fenusa pumila* Klug, on birch, which now extend from the Atlantic coast to the Great Lakes, have already produced both these results, particularly in the Atlantic coast region where the injury has persisted longest and has been most severe. The spruce budworm outbreaks caused an enormous loss in the reduction of diameter growth in stands which eventually recovered a fair degree of health.

When one considers the total mortality in the forest caused by the major insect enemies and, in addition, the depreciation in forest values caused by changes in forest composition following insect outbreaks, and the reduction in growth and health of the forest which has resulted directly or indirectly from insect damage, it becomes apparent that the effects of insect attack on the forests of Eastern North America have been tremendously injurious and that the prevention and control of injuries caused by forest insects constitute a problem of vital importance in forest protection.

## INTERRELATIONS BETWEEN INSECTS AND THE FOREST ENVIRONMENT

The investigation of great forest insect outbreaks is continually extending our knowledge of the relations between the insects and their forest environment. An investigation of this kind may include within its scope the study of a large part of the forest complex, together with the climate and soil conditions of the district. The interrelations of the insects with any of the other components of the forest or their responses to climatic or other environmental factors may be intimately concerned with the progress of the insect epidemic, or in a more general way, may affect the health or development of a portion of the forest itself. The present discussion of these relationships and of the factors which influence the economy of forest populations must necessarily be very brief, but some of the problems involved therein are of great interest and importance in any general consideration of forest development.

A thousand fascinating relationships exist between the insect fauna and the other life of the forest, between the insects and their host plants, their insect parasites and predators, the birds, mammals and other animal life and the fungi.

*Insects and Their Host Trees.* Some insects feed on only one or a few closely related species of trees, whilst others readily attack a wide range of host plants; some attack bark or wood only when it presents certain definite physical or chemical characteristics and others appear to be much less particular in their choice; some species follow their host trees throughout the latter's range on the continent and other species are confined by climatic or other factors to a comparatively narrow area. The destruction of great quantities of a primary host in a region may result either in the virtual disappearance of an insect species or in forcing it to concentrate on secondary hosts.

*Insect Parasites.* The relations of forest insects to their parasites have received a great deal of study. Many attempts have been made to effect the control of introduced pests through the introduction of their native parasites. Successes and apparent failures have attended these efforts, but certain of the successful ventures have been so impressive that this method of establishing a natural control for introduced insects is being generally applied. In addition to the specific parasites of the introduced pest, it may sometimes be profitable to import the same species of parasite or even different species with suitable life-histories from other species of hosts. An interesting situation is now appearing in that parasites which were established in a district for the control of an imported insect are proving to be of service in checking the subsequent invasion of other species.

The utilization of native parasites through their multiplication and distribution for the control of outbreaks of native forest insects has received much less attention. Some extensive outbreaks of native defoliating caterpillars have evidently been controlled by parasites, and the possibility of utilizing parasites in such cases should be further explored; but in the case of many serious forest infestations the degree of parasitism has rarely become high enough to be considered of great importance. The effect of parasitism with many forest species is probably to check the multiplication of the host beyond the endemic condition and to lengthen the time between outbreaks.

*Insect Predators.* The insect population serves as a necessary food for birds and mice and even for fish in the lakes and streams. On the other hand, both birds and mice exert a certain, if usually minor, controlling influence on insect multiplication. Woodpeckers, for example, have destroyed as much as 90% of the broods of *Dendroctonus piceaperda* in small outbreaks. They are probably effective at times in controlling sporadic outbreaks and in hastening the decline of more extensive ones, although they are usually of little importance at the height of great infestations. Mice and shrews destroy large numbers of insects which hibernate in the debris on the ground surface. These animals have apparently been helpful, for example, in reducing some larch sawfly infestations and during the past two years they have destroyed approximately 40% of the hibernating larval cocoons of the European spruce sawfly in the Gaspé peninsula. Spiders, ants, wasps, syrphus flies, clerid and carabid beetles, and others are sometimes of local importance in checking the increase of injurious forest species.

*Forest Insects and Fungi.* Forest insects and fungi have many interrelations. Insects are sometimes responsible for facilitating the invasion of the bark and wood which they attack, by species of parasitic fungi. Such a relation exists between *Cryptococcus fagi* Baren. and the *Nectria* which follows its attack on the bark of beech and which eventually kills the trees. On the other hand, entomophagous fungi and other organisms are sometimes effective in destroying many insects and may even become an important factor in the control of rather extensive outbreaks.

A very interesting association between certain bark-beetles and fungi causing blue stain in the trees attacked by the beetles has been brought to light recently on this continent by the studies of Dr. Craighead and Dr. Rumbold (*4*). It has been demonstrated both in Europe and in America that where they are introduced artificially into the inner bark and cambium the fungi are able to kill the trees without the aid of the beetles. It is probable also that some species of *Dendroctonus* would kill the trees without any assistance from the fungi. It remains to be proven whether the beetles or the fungi receive the greater benefit from this partnership. These studies have opened a field of great scientific interest and with possibilities of application in practical control.

It is apparent that the tunnels of bark and wood boring insects must aid in introducing the spores of wood rotting fungi into stumps, fallen trunks and other debris on the forest floor, but there is little exact information yet available on this subject.

A remarkable case of symbiosis exists between certain wood boring beetles, known as ambrosia beetles, and definite species of fungi, called ambrosia fungi, which invariably accompany the beetles in their tunnels, clothing the tunnel walls with a luxuriant growth of conidiophores during the time the larvae are developing. A few of these beetles attack living trees and are of some importance in the forest economy; *Corthylus* for example injures hard maple seedlings, and several species on this continent are injurious to commercial timbers. These fungi, therefore, upon which the beetle larvae are solely dependent for food, also play a definite part in the forest development.

The ambrosia beetles excavate slender tunnels deep into the wood of the trees they inhabit. The hyphae of the fungus penetrate the cut cells and the vessels for several millimeters and eventually stain the tunnel walls dark brown or black, but they cause no other injury to the wood. The forest of conidiophores which projects into the lumen of the tunnel, in the case of many species, serves as the sole food of the larvae and forms an important food of the adult beetles. On the other hand, these species of fungi have been found *only* in the tunnels and in the alimentary canal of the beetles. A perfect case of symbiosis appears to have been established.

Shortly after the tunnels have been commenced, germinating thick-walled spores are found on bits of excrement on the walls of the tunnels, and the hypae, growing rapidly, produce vertical chains of conidia which ripen terminally as large *thin-walled spores*. These latter are distributed by the beetles over the tunnel walls as fast as the excavation proceeds and, germinating rapidly, they give rise to hyphae which rapidly cover the tunnel walls with a dense forest of erect conidiophores like the pile on velvet. The thin-walled spores of the species I have studied go through the conidial cycle in drop cultures in about 60 hours. Within a very few days the production of thin-walled conidia ceases and thereafter only the thick-walled spores are produced. The latter will germinate, apparently, only after having passed some time in the alimentary canal of the beetle. Several genera and a considerable number of species of these fungi accompany the ambrosia beetles of North America, but none has yet been described. Many interesting relationships exist between different species of beetles and the particular food fungus which accompanies them. A somewhat similar fungus association is found elsewhere among insects, notably with certain gall-making species and in the coleopterous family *Lymexylidae*.

## Factors Influencing Outbreaks

One of the most important inquiries before entomologists today concerns the causes which influence the rise and fall of great insect outbreaks. Definite facts have been learned respecting the decline of a few insect epidemics in the forest, but too little is known of this subject as yet to justify much generalization.

Forest epidemics are usually well advanced before the entomologist has an opportunity to commence his studies. It has rarely happened that a great forest outbreak has been investigated throughout its full course, and it is partly owing to this situation that our knowledge of the factors affecting the rise of outbreaks is even more meagre than that of those causing the decline. There is much valuable information to be gained by an intensive environmental study of injurious species throughout the complete outbreak cycle, from the peak of one outbreak throughout the years until the peak and decline of the next.

The causes behind the rapid increase or decrease of insect populations must usually lie in the field which has been termed, very aptly, the "environmental resistance." There are at present two great difficulties in dealing with this matter, one being our lack of knowledge of definite facts, and the other that many of the factors may change very greatly from one outbreak to another and from one season to the next.

It is probably too early to make definite statements regarding the constancy of the factors in the biotic potential, but it is very apparent that those of the environmental resistance vary so greatly that it is useless to attempt an estimation of the total resistance in the case of a field problem from data obtained in a previous investigation.

Some forest species are probably held in check effectively by parasites and predators. Some outbreaks of forest tent caterpillars have been controlled by flacherie, and others by a combination of parasites and fungi. On many occasions native parasites and diseases have been among the most evident factors in controlling severe outbreaks of certain forest insects, and they appear to be responsible, in some cases in large measure, for producing the phenomenon of periodicity in connection with infestations.

*Climate and Weather*. The influence of weather and climate in regulating the distribution and the activities of insects is of great importance. Forests, in general, have climatic characteristics which differ in many respects from those obtaining in the open country. The work of Lorenz-Liburnau and others in Europe and that of Fernow and Zon in America has brought out many features of the forest climate which are gradually being applied to the study of insect life in the forest. Whilst the general effect of the forest cover is one of moderation and equalization of extremes, there are several phenomena peculiar to forest conditions which appear to have a special significance. Such are the reversal of temperature gradients in the spring and fall, the increased precipitation over forested areas, and the retention of humidity under the forest cover. This study is still in its infancy but it holds considerable promise for the explanation of such insect activities as the vertical distribution of species, migration into and out of the forest, and variations in life-history and habits.

Differences in light and in air circulation appear to have a marked effect on many species. In many instances, particularly in the study of boring species, the micro-climate requires thorough investigation. Undoubtedly insects have become inured, to some extent, to many fluctuations in weather conditions, but these fluctuations are often sufficiently great to produce significant effects on density of population, local distribution, or modification of life activities.

Many outbreaks of defoliating caterpillars have apparently been controlled by cold, wet weather affecting the first few larval instars; or by heavy beating rains at the time of pupation, after the protecting foliage had been destroyed; or by starvation through exhaustion of the food supply; or by certain other conditions which have been fairly well established in the cases of definite outbreaks. On the other hand, peculiar climatic conditions may favour the development of great insect outbreaks. The appearance of extensive bark-beetle infestations following periods of excessive dryness is a case in point.

*Changes in Species Virility.* The epidemic of the black-headed budworm in Cape Breton island, already mentioned, presented interesting features in connection with the cause of its decline. The outbreak was discovered in 1929 on some 200 square miles of territory. The infestation was so severe that the trees were reddened over a large part of this area, although an inspection of the same district in the previous summer had disclosed no such injury. It is evident that the outbreak developed with great suddenness and apparently in one season. In 1929 the eggs were extremely abundant, although the average number laid by the females was not ascertained. In 1930 the outbreak had spread over almost 500 square miles; but, although the moths were very numerous, they laid very few eggs either in the open or in the cages, the average per female being only about six in the several conditions under investigation. In 1931, the infestation was reduced to somewhat less than one-tenth the numbers of 1930, and parasites and disease destroyed the caterpillars so extensively that an average of less than one moth per tree was obtained on the areas studied. In 1932, the outbreak had disappeared and no trace of fresh defoliation could be found.

It is a temptation to speculate with even these meagre data. If the oviposition average in 1928 and 1929 had been 100 or more (which may very well have been the case since dissection showed the females to be capable of laying as many as 150 eggs and it is known that the oviposition in 1929, at least, was extremely heavy) the evident decrease in the oviposition of the females over a large extent of territory would explain the rapid decline of the outbreak. The weather conditions of that district during the spring months of 1927-1929 varied only very slightly from the normal and could hardly have affected oviposition to any marked degree.

The comparison by J. J. deGryse (unpublished report), of a large amount of carefully compiled data obtained during three years succeeding the peak of an outbreak of the maple leaf cutter (*Paraclemensia acerifoliella* Fitch) shows a yearly increase in the general debility of the strain. The eggs, although normal in the average number laid per female, showed a yearly decrease in the number hatching. The larvae showed a yearly increase in mortality while in the mine, a very definite yearly increase in the length of the second stage—and this in an increasing percentage of individuals—a similar progressive increase in the length of the third and fourth stages, with, as an ultimate result, a high percentage of mortality which appeared to be due solely to congenital weakness. This weakness was further manifested throughout the life of the individual by a lack of ordinary activity, such as slow and irregular feeding.

The suggestion is made in a report (unpublished) by Norman Criddle and R. H. Handford concerning a recent outbreak of the Bertha armyworm (*Barathra configurata* Walk.) in Manitoba that the sudden termination of the outbreak appeared to be accompanied by a somewhat similar decrease in virility.

This insect, which had been of local annoyance in Saskatchewan for a number of years previous to 1927, began in that year to increase in Manitoba, and by 1929 it had become so abundant that large areas of sweet clover and flax were destroyed. Its activities at this time extended from Manitoba and North Dakota to British Columbia. Then, in 1930, after hatching in large numbers, the species suddenly dropped into insignificance. At the Treesbank laboratory a study of the insect was being made at the time and a number of larvae were under observation, most of which had been reared from the eggs. The eggs proved to be mostly fertile and definite numbers of larvae were obtained and fed on sweet clover, one of their favourite food plants. They were reared under similar conditions to others which had reached maturity in 1929, yet despite every attention these larvae all perished. A few died in the first instar but most of them survived until the second or third stage. As they increased in age they steadily became more sickly, extended on beyond the period of normal moulting and finally died. This behaviour occurred not only in the laboratory but observations in the field showed that the larvae were behaving there in a similar manner and finally the entire outbreak collapsed. Scarcely a larva was present in 1931.

It should be added that while both parasites and diseases were present, these in combination did not account for more than 20% of the larvae. Thus the rapid subsidence of the outbreak seems to have been wholly due to a physical weakness in the larvae. Whether this weakness was brought about by weather or by some other factor or a combination of agencies was not determined.

The subject of virility of the strain is exceedingly complex and offers apparently a promising field for research. There is the possibility, particularly following the peak of an outbreak, of a subnormal sexual fertility appearing in either sex which may be disclosed by a reduction in the number of fertile eggs laid by the females, or a congenital weakness which may result in egg mortality and lengthening of the larval stages with greater susceptibility to disease and higher mortality. The same final results have evidently been caused by inclement weather conditions. The question of a reduction in the virility of bark-beetle broods during the latter part of an outbreak has been the subject of investigation recently by European workers, and data on the same subject are being collected on this continent. A sudden increase in virility, on the other hand, may be a major factor in the sudden rise of some outbreaks.

*Food Supply.* The abundance of a suitable food supply is obviously necessary before a great insect infestation can develop, but vast supplies of the preferred host of an insect have existed for long periods before very extensive trouble of this kind has developed. Under such conditions, small outbreaks have occurred here and there over the forest during long periods and suddenly, from several distant points of origin, a series of outbreaks has developed and in some instances merged into a great infestation. This is, in effect, the history of the spruce budworm outbreak of Eastern Canada and Maine. There was unquestionably a vast food supply of balsam fir in the forest regions between the Atlantic Coast and Central Ontario. Extensive cuttings and fires during the previous generation had favoured the increase of balsam over the southern part of this area; but that could hardly be said of the northern portion, and it was in the north, between Lake Expanse and Lake Manawan, in northern Quebec, that the earliest outbreaks are supposed to have occurred.

During the previous century, a series of budworm outbreaks, some of them of considerable size, had occured in the forests of Maine, New Brunswick and Southern Quebec, but there are no records for that period from Northern Quebec and Northern Ontario. There was an immense amount of balsam fir in the Gaspé peninsula and along the North Shore of the Gulf of St. Lawrence, yet the budworm outbreak did not develop in either place. The extensive upland plateau in northern Cape Breton island has carried a pure stand of balsam, probably for countless ages, and yet, although the budworm occurs in that stand and has even been reported as rather abundant at times in the northern portion, no budworm outbreak of any importance has left any record of its occurrence in that area.

The hemlock looper is a common insect in the forests of New Brunswick and Nova Scotia; both balsam fir and hemlock occur there abundantly, and the climatic conditions are probably more favourable there than in Newfoundland or on the North Shore of the Gulf; nevertheless no important outbreaks of this insect have been reported from the Maritime Provinces for many years.

The food supply, such as extensive pure stands or rich mixtures, is a pre-requisite for an outbreak, and under our forest conditions such stands are constantly in danger, but the cause of the outbreak must be sought elsewhere.

*The Influence of Forest Types.* The abundance of forest insect epidemics in recent years has been ascribed sometimes to the alterations in forest types which have resulted from man's activities. On this continent so much injury has occurred in virgin stands and in both mixed and pure stands which have resulted from cutting operations, that the planted and managed forests of Europe have been looked on with envy in the past in the belief that they were less susceptible to insect attack. On the other hand, European forests have suffered so severely from insect depredations that foresters and entomologists in Central Europe formed the opinion that their insect troubles were due largely to their artificial and managed forests and for a time they thought with envy of our virgin stands and mixed forests as being immune from great insect outbreaks. Large areas of forest containing only one or two species are considered to favour the development of outbreaks by certain insects and, other things being equal, it will probably be best to encourage the growth of mixed forests in so far as management can effect it. It should be noted, however, that overmaturity of the stand has been responsible for much of the mortality during recent insect outbreaks in pure stands, and, also, that there has been some evidence that insects which usually inhabit pure stands by preference may be able to adapt themselves readily enough to the conditions in a mixed forest. There is probably little reason to have much confidence in the general immunity of any type of stand, although certain types certainly have an advantage with respect to particular insect species.

A rather peculiar case of natural protection has occurred in a larch forest north of Belleville in Ontario. This forest is more than a mile long and nearly as wide, and is composed mainly of larch growing in a wet alder swamp. The water table is at the ground level throughout the year, except for a short period in midsummer, and for that reason larch sawfly cocoons have probably not been able to hibernate successfully. The trees vary in age in the main stand from 90 years to 216 years, and consequently they have escaped completely the larch sawfly outbreaks. A similar case has been reported from Eastern Manitoba and Graham has referred to other instances observed in the Lake States.

*Groups of Outbreaks.* It is somewhat peculiar that several or many outbreaks of the same species of insect sometimes arise at nearly the same time on widely separated areas. The spruce budworm outbreaks have already been mentioned. The outbreak of the black-headed budworm (*Peronea variana*) in Cape Breton island, was paralleled by an outbreak of the same species on the coast of British Columbia and in parts of Western United States. The series of outbreaks by the hemlock looper at nearly the same time in the Lake States, Ontario, and the North Shore of Quebec, already described, and recent outbreaks of the Douglas fir tussock in Western United States and British Columbia afford other striking examples.

The eastern spruce bark-beetle (*Dendroctonus piceaperda*) appears in outbreaks, periodically, from the Atlantic Coast to Northern Alberta. Two such periods of infestation are recorded and several others are to be inferred from the older records. In the last instance outbreaks occurred in the Gaspé peninsula, Nova Scotia, New Brunswick, Central Ontario, Manitoba and in Northern Saskatchewan, all within a few years of each other. At the present time there is an extensive outbreak in the Gaspé peninsula and smaller infestations in parts of Nova Scotia, although for the previous few years there had been no outbreaks reported. If history repeats itself in this instance, we shall discover outbreaks of this beetle in Ontario, Manitoba and Saskatchewan within the next two years.

For the last few years there has been an unusual abundance of various sawfly species in Canadian forests. The larch sawfly was increasing in the East until two years ago and has since declined; the spruce sawfly of the

Gaspé is a new occurrence; there have been three hitherto unknown species of jack pine sawflies concerned in an extensive outbreak in Central Ontario and a new species had just before been recorded defoliating jack pine in Minnesota; the fir sawfly occasioned the most extensive outbreak ever recorded in Canada for that species in the Sault Ste. Marie district in 1930; an undescribed species of sawfly has been defoliating hemlocks in Queen Charlotte islands for the last two years; and a considerable number of other species might be added to the list. Climatic conditions in these widely separated regions are so diverse that they could hardly favour the development of the same insect at so nearly the same period of time, and in any case, how shall we explain this extraordinary plague of sawflies?

*Periodicity.* Certain of our well-known forest insects have appeared in extensive outbreaks at more or less regular intervals. The tent caterpillars, the fall webworm, and the birch leaf skeletonizer will serve as examples. During the last 40 years, extensive outbreaks of the birch leaf skeletonizer have occurred in the forests of Eastern Canada at intervals of almost exactly 10 years, and have lasted approximately three years before subsiding. In the case of some insects, the parasites, predators and diseases appear to play a part in maintaining this periodicity; with others the outbreaks may be dependent on the development of a new food supply, either through growth or by the overthrow of timber in windstorms, or by other causes which may present a measure of real or apparent regularity.

A striking correlation has been shown by Criddle (*5*) to obtain between sun spot maxima and the greatest abundance of both grasshoppers and grouse on the Canadian prairies during the last 40 years. The possible relation between the sun spot phenomena and insect abundance is evidently deserving of a much wider investigation than it has yet received.

No combination of the known agencies appears to be sufficient to explain all the phenomena involved in the development of groups of outbreaks and periodicity, and it is possible that there is some factor influencing the rise of great insect outbreaks that has not yet been discovered.

In the whole field of Entomology there is probably no subject of deeper scientific interest or of greater practical importance than the general question of the causes underlying the appearance and progress of great insect epidemics. Hidden among its secrets are the possibilities of forecasting outbreaks and taking measures for their prevention or mitigation, predicting their progress and providing for control or salvage, and laying intelligent plans of management for obtaining a measure of insect immunity.

The factors involved and their interrelations are manifold. Any component of the forest may be concerned in the matter, as well as various influences from without. The study will draw upon all the resources of Entomology—Taxonomy, Morphology, Biology, Bionomics—and extend into other sciences, but it is primarily a study of the forest environment. If every opportunity is taken to prosecute the study of forest insect bionomics, the gradual accumulation of data eventually may enable many of these problems to be solved.

*Variation in Habits.* Variations in the factors of the environmental resistance are able to effect significant changes in the habits of the same insect species. A few interesting examples of varying habits have been met with in recent investigations and many others are recorded here and there in the literature. Referring again to the spruce budworm, it was found that throughout the greater part of the eastern outbreaks the larvae hibernated in tiny silken cases on the twigs, and, appearing in the following spring at the time the buds of the balsam fir and white spruce were opening, they killed a large percentage of the buds and the new shoots before the latter had time to develop. This was a marked characteristic of the species everywhere, except in the island of Cape Breton. In that interesting country, the budworms emerged from hibernation after most of the buds had burst and the shoots had commenced to lengthen, with the result that the new shoots grew to nearly their normal length, the buds for the ensuing year developed normally at the tips, and the larvae merely stripped off the needles leaving the new twigs completely bare of foliage. Under these conditions the outbreak lasted apparently for about 15 years, instead of dying out in about 3 years, partly through starvation of the caterpillars, as had happened elsewhere.

In the cold, wet spring climate of that region, the cold and humid air conditions apparently retarded the development of the larvae without affecting so greatly the growth of the buds, so that a large proportion of the shoots were well started before the larvae appeared.

This outbreak disappeared finally under rather unusual conditions. Throughout our studies of the spruce budworm, parasites were found usually to play a minor role. In the Cape Breton outbreak, however, as in a few other localities, the parasites were rather more numerous than usual, and in 1927 the parasitism suddenly increased to more than 80% and the outbreak disappeared.

On a high plateau in northern British Columbia, some 3000 feet above the sea, a spruce budworm outbreak has been in progress for a considerable number of years in a forest composed of mountain balsam and Engelmann spruce. In that cold, wet climate, with frequent heavy rains throughout the summer, the budworm larvae develop in the first season of feeding to only the third or fourth stage without causing much defoliation, and go back to the twigs at the end of the season, spin a second hibernating cocoon, and pass the second winter therein. In the following spring they attack the foliage vigorously, causing a noticeable defoliation, and complete their course of development. The eggs are laid in the normal way and in the following year the larvae reach only the third or fourth stage as before.

There is in this case a two-year life cycle with noticeable defoliation appearing in the alternate years. The trees were not being killed by the budworm and the outbreak had apparently lasted for a considerable period of time.

The mountain balsam bark-beetle, *Dryocoetes confusus* Sw., is killing the timber in that forest rapidly and it exhibits a peculiar habit in cutting a second egg-tunnel as an extension of the first without the labour of excavating a new entrance hole, a habit which may also be related to the climate.

Throughout the province of Quebec and the Maritimes the spruce budworm injury occurred chiefly in pure stands of balsam and spruce. In mixed stands of hardwoods and balsam, the defoliation appeared mainly on the balsam tops which projected above the crown cover of hardwoods and, as a consequence, mixed stands were considered to be largely immune from severe budworm injury. They appeared to be so in Quebec and the Maritimes;

but when the budworm outbreak developed later in Central Ontario, the balsam fir beneath hardwoods in mixed stands was destroyed to a very high degree. It is therefore far from certain that mixed stands of hardwoods and conifers will be immune against budworm invasions.

In all the infestations which have been studied in Eastern Canada, the spruce budworm fed chiefly upon balsam fir and spruce and rarely fed at all on the foliage of jack pine. In the Lake States, however, there is a budworm which is considered to be the same species that feeds by preference on the needles of jack pine, and in Wyoming there is another which prefers the foliage of lodgepole pine. In one section of the Cape Breton island outbreak, the spruce budworm showed a preference for swamp spruce, which was being killed by the defoliation, although clumps of balsam fir in the same stand were but slightly injured.

The white-marked tussock is a common enemy of elms and other deciduous trees and is found occasionally feeding on balsam fir and larch. In 1928 and 1929 two outbreaks of this insect occurred in Nova Scotia on balsam fir in which the trees were heavily defoliated over an area of many acres in each case.

The food preferences of insects have been completely changed under pressure in experimental work, and there is some reason to assume that the same result may have been produced under natural conditions in the forest.

*Host Selection.* A very definite preference in the selection of their hosts is exhibited by many forest insects. In fact, many species breed normally in only one or at most a very few species of trees, and this preference is so strongly fixed that they can be forced to breed in other hosts only under pressure of very unusual circumstances. In the case of insect species which have only a few closely allied host trees it has sometimes been assumed that the individuals which had bred on one of the host species showed a distinct preference for the same species either for food or for the purpose of oviposition. This assumption often appears to be a logical one and has not been without the support of evidence in a number of cases. It cannot, however, be accepted yet as an established principle that has general application. The habit of each insect species requires to be studied in that regard on its merits, and there is some reason to suspect that certain species will exhibit considerable variation in the strength of their preference. The difficulties that may be met with in studying this subject are exemplified by the case of the mountain pine beetle (*Dendroctonus monticolae* Hopk.), in lodgepole pine and yellow pine in Western North America. Workers in California and Oregon have held the view that an outbreak of this species occurring in a lodgepole pine forest was not likely to spread into a neighbouring stand of yellow pine for the reason that the beetles, having bred in lodgepole pine, would almost certainly attack only that tree, at least until the lodgepole stands were destroyed. Naturally, there was evidence to support this view.

On the other hand, workers in British Columbia have long been convinced that in the forests of that province outbreaks of the mountain pine beetle have on numerous occasions developed in lodgepole forests and have spread down the slopes and into the yellow pine stands below. It is difficult to obtain conclusive proof under field conditions, but a study of the development and extension of these outbreaks in British Columbia, extending over a period of many years, has convinced entomologists there that outbreaks of these beetles in lodgepole pine spread readily enough into yellow pine in the neighbourhood.

Experimental work with large cages has disclosed no evidence of any decided host selection. Infested lodgepole pine logs were enclosed in cages with an equal number of freshly cut lodgepole pine and yellow pine logs, and infested yellow pine logs were treated in the same manner. Several of these cages were employed in each of three successive years. In no instance was any preference shown. The beetles which emerged from yellow pine or from lodgepole pine went in approximately equal numbers into the yellow pine and into the lodgepole pine logs provided in the cages. It should be noted that this beetle breeds readily enough in cages of the type employed in the experiments, and there is, therefore, little reason to suppose that the caged conditions distracted them from the exercise of any normal preference.

It seems probable that the distinct differences in the course of outbreaks by this beetle, which have been noticed between those in southern British Columbia and those occurring in Oregon and California, may be paralleled by distinct differences in the matter of host selection.

*Individual Selection of Trees.* The evident selection exerted by the insects for individual trees or for trees in a definite condition of health is another matter of the greatest importance. It is well known that even at the height of a severe outbreak certain individual trees may be more or less completely exempt from injury. Many examples of this individual immunity have appeared in the course of investigations, and it has sometimes been suggested that immune races of trees might be propagated from these individuals with great advantage to forestry.

It is well known that most species of bark-beetles, even those which at times cause the most destructive outbreaks, select at normal times trees in a weakened or dying condition. *Dendroctonus piceaperda* Hopk., which breeds in the bark of spruce, normally selects for attack only the over-mature, weakened or dying trees, windfalls or logs. Under normal forest conditions, the species exerts a very definite selection for bark in a weakened or dying condition. When, however, the species has increased to enormous numbers, as often occurs in extensive windfalls or in great quantities of large slash left in cuttings, and a destructive outbreak develops, the beetles attack with apparent freedom all conditions of trees in the stand, excepting the small diameters of less than six inches. In one instance, it was found that 13% of the trees which were killed by the beetles had previously been growing as fast as any in the stand, 20% had been making the average diameter growth for the whole stand, and the remainder had been growing more slowly than the average.

It has frequently happened in Eastern Canada that an outbreak of this species killed approximately 50% of the larger spruce in an infested valley and then died away. Is it possible that the beetles are exerting any selection in their attack on the trees during the height of an outbreak, or that there is any reason why they attack that 50% and not the other?

Up to the present time the investigations of entomologists on this point have not been conclusive. It appears that resin production has little to do with the matter, all degrees of resin flow being exemplified in the trees which are killed. Also the rate of growth does not appear to be related in white spruce with the production of resin.

Many peculiar vagaries in the matter of selection come to light in the study of trap-trees in bark beetle control. One incident will serve for illustration. An apparently healthy spruce, 10 inches in diameter was felled on June 15, 1932, and left lying on the ground. One week later only a few beetles of *Dendroctonus piceaperda* had entered the bark of the felled tree, but in the meantime a great swarm of beetles had attacked a healthy, 13 inch spruce standing nearby. Both trees had been retarded by sawfly defoliation for the previous four years. Cases such as this appear to suggest that under certain conditions individual trees may exert a definite attraction.

It is probable that the attraction which dying bark exerts on these beetles under normal conditions must be associated with chemical changes in the trees, presumably in the cell sap. Researches on the chemical changes which occur normally in trees from month to month throughout the season, and in trees which are slowly or rapidly declining in vigour should yield invaluable results.

There are many such problems in the forest which lead directly into the fields of biochemistry and plant physiology. Their solution will be achieved only through co-operation in research.

*Reaction of Trees to Insect Attack.* The reaction of the trees to the insect attack is a matter of the greatest interest and a problem that abounds with difficulties. In the case of species which normally attack trees that are unthrifty but to all appearances still alive, it is sometimes a matter of dispute whether the insects have actually killed the timber or whether they have merely selected trees which had already been weakened by other causes beyond the point of recovery. The attack of the balsam weevil (*Pissodes dubius* Rand.) on weakened balsam fir is a case in point. The broods of this species are invariably developed in trees which are unthrifty and which are making little or no diameter growth.

The broods develop to maturity only in trees which die rapidly shortly after the attack. If the infested tree does not die the larvae succumb when only partly mature. Unless the larvae are able, through the effect of their tunnels cut in the inner bark, to kill the weaker trees, it is evident that the females often make grievious mistakes in their selection. The beetles of this species excavate feeding punctures freely in the bark of healthy trees and, during a recent investigation in New Brunswick there appeared evidence that the effect of these feeding punctures, made over a period of years, may weaken trees to such a degree that eventually the broods can develop to maturity in the bark.

*Insect Populations.* The so-called population studies, in which an attempt is made to follow accurately the numbers of the species throughout the full course of its development, have achieved very interesting and practical results. In many cases, no doubt, the results have been much more interesting than practical, but the value of these studies is unquestioned. The very thoroughness with which the investigation must be planned and conducted through all its stages to completion ensures the best opportunity for obtaining the most essential data, and for discovering obscure habits and associations of the insects. The estimation of the original egg population, the larval population in each instar, the pupal population and finally the adult emergence, conduct and oviposition, together with the mortality in each life stage and the causes of it, serve as a background on which a most complete investigation of the insect and its associations can be built.

The studies on bark-beetle populations in Europe made recently by Seitner, Golovyanko (6) and Iljinski (7) are excellent examples of a study of this kind directed to a practical end, in those cases, the determination of the number of trap trees required to absorb all the beetles that would be produced per unit area. The formulae that were developed no doubt represented the conditions met with in the outbreaks that were investigated, but the results of investigations of this sort cannot yet be applied generally to forest outbreaks. They must be made, in great part at least, on each individual infestation. Many such studies will be required on any insect species, representing many varied conditions, before much generalization can be made.

*Forest Insect Biologies.* There is a great need for more general knowledge of forest insect biologies. In the Cerambycidae and Buprestidae, not even the host tree is known for a number of the species, and in the case of these and many other forest insect groups there is an astonishing lack of information on the biologies of even some of the commoner species. In the general field, there is very little advance to be found in the literature since the time of Packard's 5th Report and Felt's Park and Woodland Insects. A great deal of information has been obtained, it is true, but the greater part of it has not yet been published. This is one field in which the young investigator can make sure and valuable progress.

The practical importance of studies in insect habits may be illustrated by reference to the generations and broods of bark-beetles. Until very recently, it had been assumed that many common species of these beetles, *Dendroctonus*, *Ips*, *Pityogenes*, and others, exhibited annually a series of overlapping generations. Through a series of careful investigations it has been shown that most of the bark-beetles in Canadian forests have, at most, only one generation each year, but that many species produce two distinct broods each season and in some cases even more. The same females cut one tunnel in early summer, lay the complement of eggs, feed for a short time and then emerge and cut a second tunnel elsewhere and deposit a second batch of eggs. The progeny from the first tunnel emerge early in the following summer; that from the second tunnel may emerge late in the following summer or may carry over in the bark until one year later, making a two-year life-history for the late season brood.

The same females of *Polygraphus rufipennis* Ky. have produced as many as three such broods in one season and lived over the winter to produce a fourth brood in the following season. Some species of northern origin, *Dendroctonus johnsoni* Sw. and *D. rufipennis* Ky., for example, have normally a two-year generation. It is possible that in the southern part of the continent some species may have more than one generation each year; but it has not been found to occur in the Canadian forest in either the East or in British Columbia. The fact that the parent beetles normally emerge shortly after the first tunnels are completed and enter other trees has an important significance in connection with control measures.

Overcrowding the brood sticks in cages has resulted in inciting a species which has normally only one brood per season to cut three separate tunnels and lay three batches of eggs. *Dendroctonus* species habitually overcrowd many of the trees they attack, but it is not yet known what effect this habit may have on the number of broods produced in the open.

It has also been learned that many species of bark-beetles belonging to the genera *Ips*, *Orthotomicus*, *Trypodendron*, and others, have the habit of leaving the brood trees during fine days in the late autumn and going into hibernation in the moss or under the litter beneath the tree. It seems an extraordinary habit for these beetles, but proves to be rather common in a number of genera. In the case of *Ips pini* Say and *Ips calligraphus* Germ., the majority of the young brood hibernate on the ground and a smaller portion cut food tunnels in the tops of dying trees. It appears that these few beetles in the tops have been able in the past to deceive us into a belief that burning the trees was sufficient for control and have sacrificed themselves for the benefit of the main population which was safely hidden under the litter.

The bionomics of forest insects is now receiving much greater attention than ever before, and a considerable amount of data on this subject has already been accumulated. Unfortunately, only a small proportion of it has appeared as yet in the literature. Ecological studies require this collection of data in large amount, and its subsequent collation and study occupy a great deal of time. Unless the results of the research together with the significant data are published, a large part of the benefit which should accrue is lost and much valuable time is wasted. Researches of this kind are perhaps as difficult as any in the field of Entomology and are usually of little value unless directed by well-trained and experienced investigators.

Twenty years ago the criticism was made, and with reason, that entomologists were paying too little attention to the bionomics of the insects they studied; today the criticism is being made by many economic entomologists that the schools have been paying too little attention to the fundamentals of entomology. It goes now without saying that every young entomologist should receive a sound training in the principles of bionomics, but it is surely quite as important that he have a thorough grounding in the classification, structure and general habits of the organisms which are to be the subject of his future investigations. When one considers the frequency with which undescribed species or unknown species appear in the course of our investigations, the difficulty in obtaining any reliable identification of collections in many important insect families, the paucity of our entomological literature on taxonomy—except in a few favoured groups—during the past half generation, and the not too hopeful prospect for young taxonomists to take over the load from those few stalwarts who are now bearing it for us so nobly, there is a tendency to hope for a revival in the study of the "three Rs" of Entomology, Taxonomy in association with Anatomy and Biology.

In concluding it may be said that the major forest problems include so many interrelations between various components of the forest complex that they can be dealt with successfully only by co-operative researches in several fields of science. The investigation of a forest insect outbreak may lead directly into research in silviculture, in mycology, in biochemistry, in plant physiology, and no one knows how much higher mathematics may be needed to deal with the data that may be accumulated in its course. It is a satisfaction to know that entomologists are realizing the need for this co-operation with other scientific men, for, without any doubt, therein lies the greatest hope for the solution of our most difficult problems.

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# PEACH CANKER INVESTIGATIONS[1]

## I. SOME NOTES ON INCIDENCE, CONTRIBUTING FACTORS AND CONTROL MEASURES

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[Received for publication May 16, 1933]

Throughout the peach-growing districts of Ontario, canker is recognized as one of the more serious diseases that infest the peach, linking up cultural and pruning practices with "die-back" of twigs and winter-injury and with the brown rot problem. Few, if any, peach orchards are free from canker; many of the older ones are seriously impaired by it, or its aftermath—heart-rot, and few of the younger ones escape its ravages.

During the years 1912-1917, McCubbin (*6*), then officer-in-charge of the St. Catharines Laboratory, carried on extensive investigations into the canker problem in the Niagara district. As the laboratory at that time had no orchard of its own, the work was done in several commercial orchards and observations were made, for the most part, on bearing trees.

The objects of the present investigations were in part to study the problem as it applied to the early as well as the later stages of an orchard, and to find if possible means for the control of canker by prevention. The scope of this paper is confined to the discussion of material obtained from intensive surveys conducted in the experimental orchard—the property of the laboratory—and to the formulation of such control measures as are suggested thereby. The former phase resolves itself mainly into the incidence of canker in different plots, the enumeration of points of origin of cankers, and a discussion of their relative importance. Isolations and inoculations, the causal organism or organisms, and other phases of the problem will be dealt with in future papers.

## REVIEW OF THE LITERATURE

Although considerable work has been done on "die-back" of the peach and other stone fruits, there is comparatively little literature on canker in peaches. Caesar (*2*) reports that canker was not troublesome in Ontario until 1908. Rolfs (*7, 8*), Walton and Babcock (*10*), McCubbin (*6*), Togashi (*9*) and others are agreed that the disease is fungal in nature and that the fungus, *Valsa leucostoma*, gains entrance by way of wounds. Rolfs claims that buds are also foci of infection. McCubbin lists the vulnerable points in the following order of importance: twigs, killed either by winter-injury, leaf-curl or "die-back"; pruning wounds; twigs killed by brown rot; crotches; dead buds; wounds other than pruning; frost cracks and blossoms blighted by the brown rot fungus. He also states that "Those districts, where the soil is hilly, and where there is deep sand with good drainage, are less affected than the low-lying, level lands where both air and soil drainage are poor. Even in the same orchard, a well-drained knoll *may be* much less subject to canker than the low, moister parts. The disease is noticeably worse also in orchards situated in hollows, or closely sheltered by woods. In many cases there is such a marked difference in adjacent orchards that one cannot help concluding that *improper orchard practice has a great deal to do with the encouragement of the disease*."[3] Caesar and Howitt (*3*) are "inclined to think that heavy pruning and heavy fertilizing, in combination with wet weather early in the growing season, may also have much effect in inducing the formation of cankers." Briton-Jones (*1*) considers that *Cytospora* (*Valsa*) is not able to cause "die-back" in strong, healthy trees and that infection is only possible after the trees have become sufficiently enfeebled, for example, by insufficient or excessive soil moisture or by starvation.

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[1] Contribution from the Division of Botany, Experimental Farms Branch, Dominion Department of Agriculture, Ottawa, Ont.
[2] Plant Pathologist.

## DESCRIPTION OF CANKERS

For present purposes, peach canker may be described as a more or less perennial lesion on the trunk or on the branches of the tree. In its early stages, it appears as a sunken, brownish area, usually disfigured by masses of exudant gum. The bark in the affected part is brownish when cut open, in contrast to the pale, yellowish green of healthy bark. Later the bark becomes shrivelled, blackish and separated from both the underlying wood and the surrounding bark. During the growing season callus formation decreases the size of the lesion, but usually, in the dormant season, the callus becomes infected either in part or in toto, so that old cankers are characterized by a series of rings caused by the death of successive overgrowths.

## DESCRIPTION OF THE ORCHARD

The laboratory orchard, set out in the spring of 1928, was subdivided into various experimental plots arranged in such a way that various schedules of sprays, experiments in the length of the period of cultivation, and experiments in pruning more or less over-lapped. This arrangement (with the omission of the pruning experiments) along with the distribution of cankers of various origins throughout the orchard, is shown in Figure 1. It will be observed that the orchard consists of two hundred and forty trees of the Elberta variety, ten trees each of the varieties, South Haven, Yellow St. John, June Elberta, Rochester, J. H. Hale, Late Crawford, Vedette and Valiant, and five trees each of Mayflower and Greensborough.

In the surveys carried on during the latter part of the growing season of each year since the orchard was planted, drawings of individual trees were made and trunk diameters were measured at two to three inches above soil level. All important wounds and all cankers were located on the diagrams, and other items of interest such as the origin and development of cankers and the fate of wounds were noted. Most wounds and all cankers were measured at each survey and at various intervals between surveys. From the analysis of the data thus accumulated much valuable information has been obtained.

## CENTRES OF ORIGIN OF CANKERS

As has already been pointed out, cankers originate at wounds or in dead areas, with a possible exception in the case of buds. In the orchard under observation, all cankers which have appeared until the fall of 1932 have been classified according to the sources from which they arose. The results of

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[3] Italics are ours.

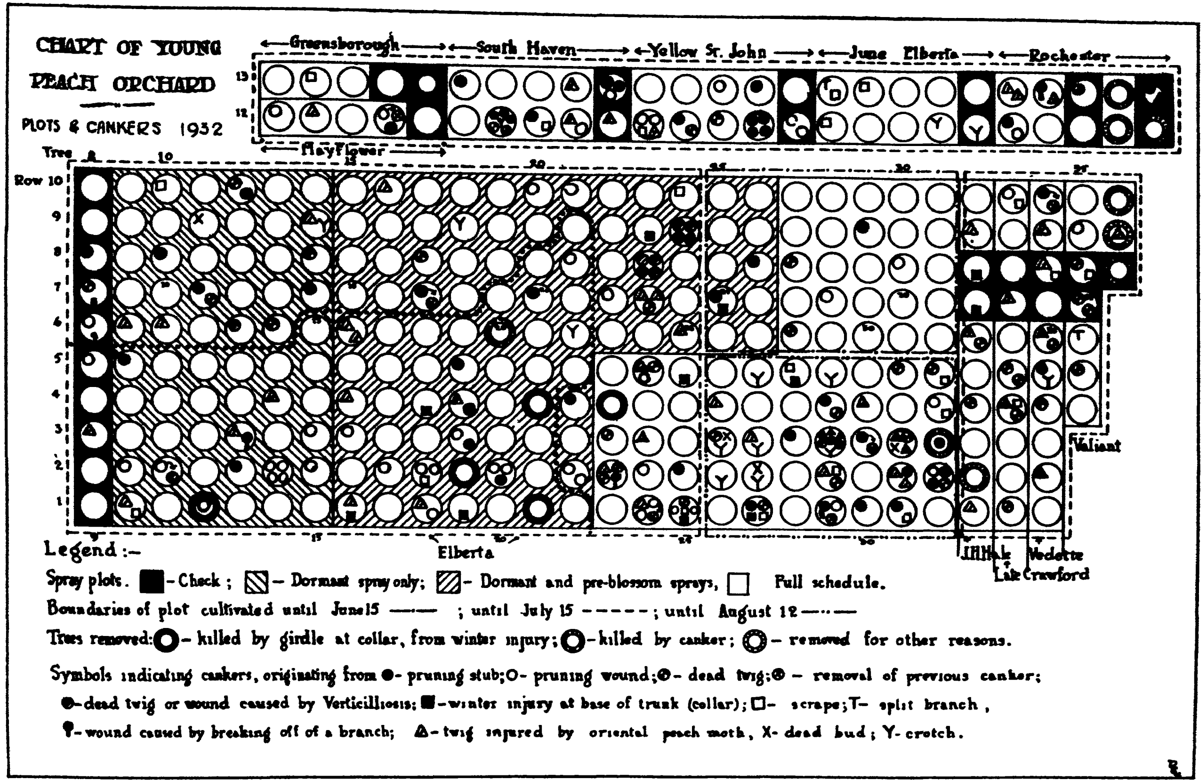


CHART OF YOUNG PEACH ORCHARD
PLOTS & CANKERS 1932
Greensborough
South Haven
Yellow St. John
June Elberta
Rochester
May Flower
Elberta
Valiant
Illinois
Lake Crawford
Vedette
Tree 5 10 15 20 25 30 35
Row 10 9 8 7 6 5 4 3 2 1
13
12
Legend:–
Spray plots. ■ – Check; ▧ – Dormant spray only; ▨ – Dormant and pre-blossom sprays, ☐ Full schedule.
Boundaries of plot cultivated until June 15 ——; until July 15 – – – – –; until August 12 —··—
Trees removed: killed by girdle at collar, from winter injury; killed by canker; removed for other reasons.
Symbols indicating cankers, originating from ● – pruning stub; O – pruning wound; dead twig; removal of previous canker;
dead twig or wound caused by Verticilliosis; ■ – winter injury at base of trunk (collar); ☐ – scrape; T – split branch,
wound caused by breaking off of a branch; △ – twig injured by oriental peach moth, X – dead bud; Y – crotch.

Figure 1. Plan of experimental orchard, showing the varieties, the spray plots, the plots cultivated for different lengths of time, and the distribution of cankers of various origins.

this classification are given in Figure 2 which indicates the points of origin and the percentage of cankers developed from each, both for individual years and for the whole period.

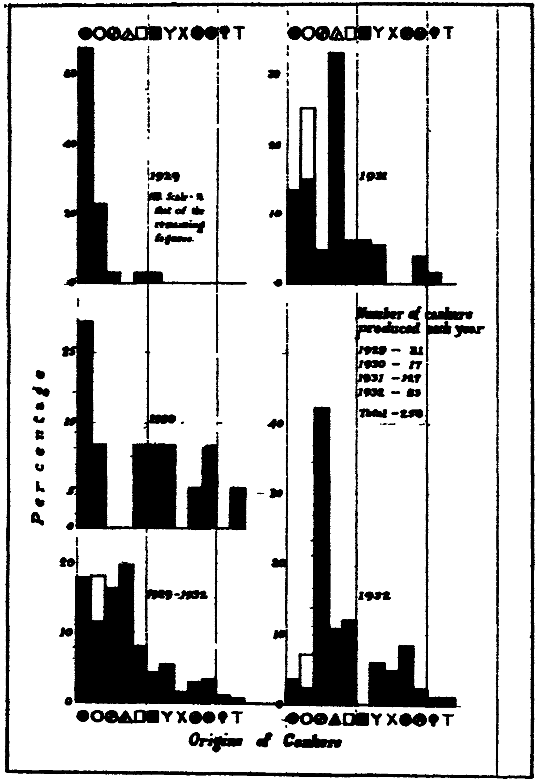
Considering first the total number of cankers, it will be seen that 72% of them originated in approximately equal proportions from four sources: twig injuries caused by Oriental Peach moth, pruning wounds, stubs and dead twigs. An additional 24.5% came from 5 sources, ranging from 8.4% to 3.1 % each, in the following order: implement scrapes, damaged crotches, winter injuries at the collar, pruning wounds caused by the removal of previous cankers, and injuries arising from *Verticillium* wilt. The remaining 3.5% developed from dead buds and from wounds caused by the breaking off or splitting of branches. These observations serve both to illustrate the relative importance of the various types of injury and to suggest, in part, means of preventing the disease.

It will also be seen, from the charts for individual years in Figure 2 that, as the trees become older, there is a tendency to shift the responsibility for cankers from pruning cuts to dead twigs, Oriental peach moth injuries, scrapes and crotches. Obviously details will vary from year to year with changes in the inter-action of a multitude of factors, but in all probability variations in the composite picture will not be significantly different from the trends already indicated.

As is well known, peach moth larvae eat their way down from the tip, inside succulent shoots, eventually to emerge through the side of the twig. Infested twigs naturally die, many of them slough off without further damage, but as shown above some of them do induce canker. The number of such cankers, of course, will fluctuate mainly with the prevalence of the moth.

The pruning cut is a necessary evil. Its importance in the canker problem largely depends on whether it is made as a stub in which part of the pruned twig or branch is left projecting, or as a pruning wound, by which is meant in this paper, a cut made flush with the surface of the parent branch. In these experiments, the pruning wounds greatly outnumbered the stubs, but in spite of that, the percentage of cankers which developed from the latter was approximately equal to that from pruning wounds, indicative of greater potential menace on the part of the stub. Incidentally, 36% of the pruning wound cankers appeared at wounds treated with either white paint, white lead, or tar, all of which are more or less toxic to exposed living tissues of the peach. Generally speaking, clean, unbruised, close pruning wounds heal rapidly, while stubs die to their base and thus provide an ideal site for canker development. For example, less than 1% of non-disinfected pruning wounds which were not healing well in the fall of 1930 produced cankers in 1931. Certainly if all pruning wounds of that year had been counted the percentage which developed into cankers would have been much less. On the other hand, 4.5% of all stubs recorded in 1930 became cankers in 1931.

Dead twigs and "die-back" twigs are certainly among the most important and fertile of starting points for cankers. Death may be due to any of a number of causes, but no attempt is made to separate them here, except to distinguish between twigs killed by brown-rot and those killed by other agencies. The former are treated in greater detail below.



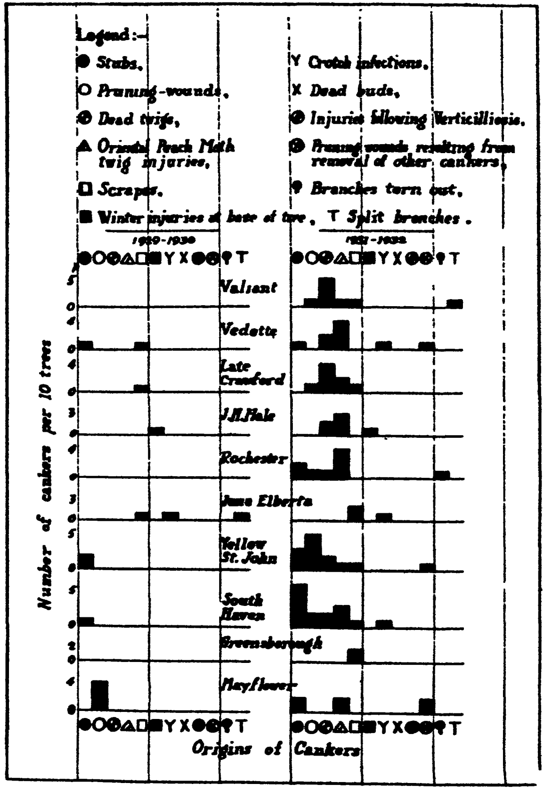


Figure 2 (left). Charts showing the percentage of cankers of various origins developed both in each year from 1929 to 1932 and during the complete period. The blank outlines in the pruning wound column represent cankers from disinfected wounds.

Figure 3 (right). Charts showing the occurrence of cankers of various origins in the different varieties.

Wounds incurred through the scraping of branches or trunks by harness, implements and so on, are fortunately numerically few in comparison to pruning wounds. Fortunately also, their number can be controlled to some extent by the exercise of proper care during the various necessary operations. It is desirable that such wounds be reduced to a minimum, because a fairly high percentage of them give rise to cankers. For example, out of 205 recorded between 1929 and 1931, 6.8% became cankerous.

Winter injuries at the base of the trunk, or collar, are important because from their location they can affect the whole tree if they become cankered and also because the tree may be girdled and killed in severe cases. The fact that 9.3% of the collar injuries of 1930 and 1931 subsequently became cankers is evidence of their vulnerability. This form of injury is not of regular occurrence although it was prevalent in 1930 when 22.4% of the trees in the orchard were affected and 7.5% of the damaged trees were killed.

Cankered and damaged crotches are also important by reason of their location. In practically every case where cankers formed the crotch was fundamentally weak, because the angle between branch and trunk was acute and because, on the upper side, there was no organic union between branch and trunk on account of the presence of dead compressed bark. Such crotches provide an ideal situation for the initiation of canker, and this condition is aggravated by a tendency for the tree to split at the crotch. The splitting is usually slight, but may be severe where growth is vigorous and the crop heavy.

The recurrence of cankers in 12% of the 75 cases of canker removal suggests the possibility that the canker-producing organism, at times, may be present in the wood considerably beyond the external limits of the lesion. Consequently it seems advisable when cutting out cankers to remove a considerable portion of the apparently healthy wood below the canker, especially where it has become well established.

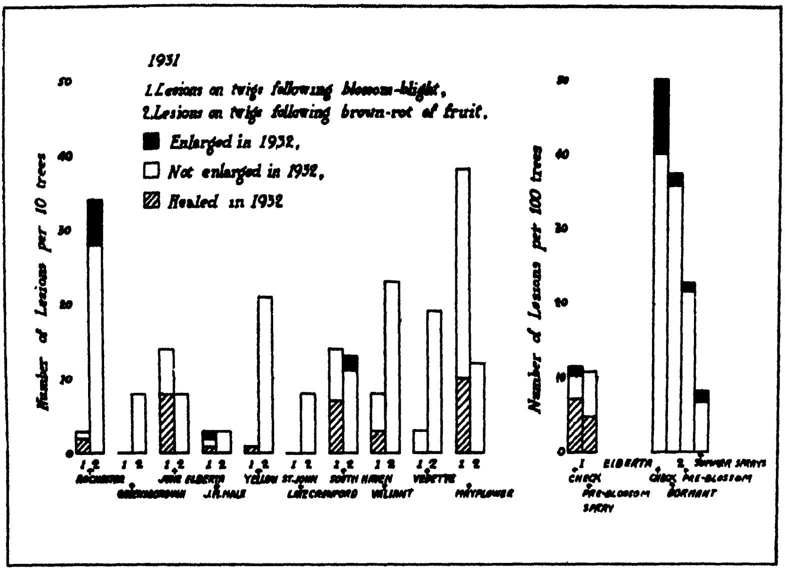
As a general rule, *Verticillium* wilt attacks young trees only and produces visible symptoms only in part of the tree, causing, apart from defoliation, two types of injury, dead twigs and dead sunken areas in the bark. Affected trees usually recover during the subsequent growing season, but sometimes the injuries become infected and give rise to cankers.

There is no doubt that infection may take place through buds and, although it has not yet been definitely established, there is some evidence that uninjured buds may be attacked. So far, dead buds have been of little importance in the direct initiation of canker, but indirectly their part may be more significant in so far as "die-back" is often the result of bud-infection.

Frequently in bearing trees, branches may be broken off or split either through being too heavily laden with fruit or through carelessness during harvest. Such injuries, of course, should be avoided as much as possible, since, besides causing more or less loss directly, they also serve as centres of infection.

## VARIETAL SUSCEPTIBILITY

The numbers of cankers of various origins in different varieties are given in Figure 3. To date there are some indications of differences in varietal susceptibility but too much emphasis should not be placed on this phase of



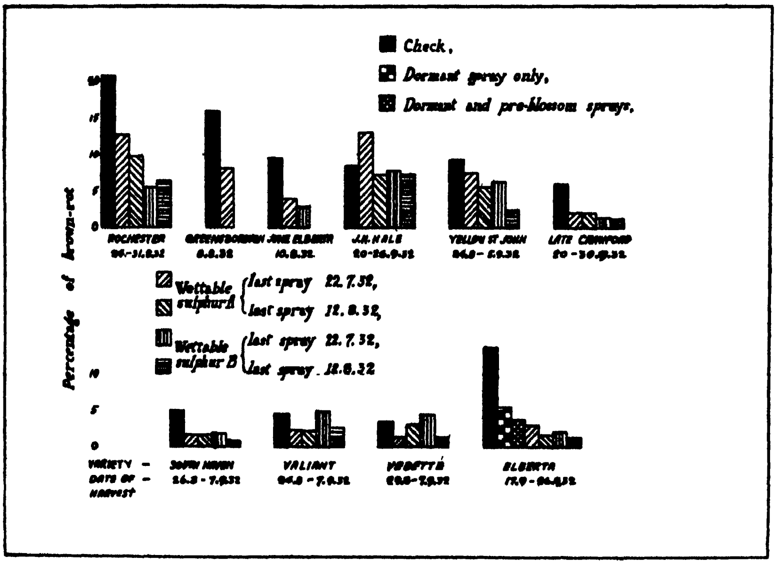


Figure 4 (upper). Charts showing the occurrence, in 1931, of lesions following both blossom blight and brown rot of fruit in the different varieties and, in the Elberta variety, in the various spray plots.

Figure 5 (lower). Charts showing the percentage, in 1932, of brown rot in check and spray plots of different varieties.

the problem at the present time. Suffice it to say that, from the data obtainable, South Haven and Yellow St. John rank among the more susceptible varieties, with Elberta, J. H. Hale, June Elberta and Greensborough among the moderately resistant.

### Relation of Brown Rot to Canker

As the *Sclerotinia* sp. causing brown rot has been cited as causing canker (*4*, *5*), counts were made in 1931 of lesions on twigs and branches caused by infection both of blossoms and of fruit. As Figure 4 indicates, the majority of the former were healed over by the following summer and only a small percentage (2.2%) showed any increase in size. A larger number of twigs were injured by means of rotted fruit while 6.2% of the lesions spread during the winter. None, however, has resulted in the formation of definite cankers. Thus it would appear that *Sclerotinia*, in spite of its ability to attack wood and bark, is not in itself a serious factor in the canker problem. However, as both types of lesion are open to invasion by canker-producing organisms, *Sclerotinia* may assume considerable importance indirectly.

### Experiments in Spraying

In order to study the effect of various spray programmes (Figure 1) the orchard was divided into plots receiving no sprays (checks), dormant spray only, dormant and pre-blossom sprays, and a full schedule, which in addition to the fore-mentioned included a shucks spray and two or three summer sprays, the last of which was applied six weeks before harvest. The materials used for the different applications, along with the rows on which they were applied are enumerated in Table 1.

Table 1.—*Summary of sprays applied to peach trees for the control of canker and brown rot.*

| Application | Material | Rows |
|---|---|---|
| Dormant spray | Lime-sulphur 1-8 | All rows |
| Pre-blossom spray | Lime-sulphur 1-50 | 1, 2, 3, 13. |
| | *Wettable sulphur A | 4, 5, 6, 12. |
| | *Wettable sulphur B | 7, 8, 9, 10. |
| Shucks and summer sprays | Wettable sulphur A | 4, 5, 6, 7, 8, 13. |
| | Wettable sulphur B | 1, 2, 3, 9, 10, 12. |

*Wettable sulphur A is known under the trade name of Kolofog, and Wettable sulphur B under that of Koloform, both are put up by the Niagara Brand Spray Company.

A glance at Figure 8 reveals that canker is not amenable to control by spraying, since it happens that the plot receiving the largest number of sprays has the largest number of cankers. On the other hand, the use of fungicides materially decreases the incidence of brown rot. The graphs for the Elberta variety in Figures 4 and 5 show that both the number of twig lesions (1931) and the percentage of brown rot (1932) were reduced even by one or two applications and especially by the use of summer sprays. From the data given in Figure 5, it is evident that some measure of control was effected in most varieties, even in one so susceptible to brown rot as Rochester. Blossom

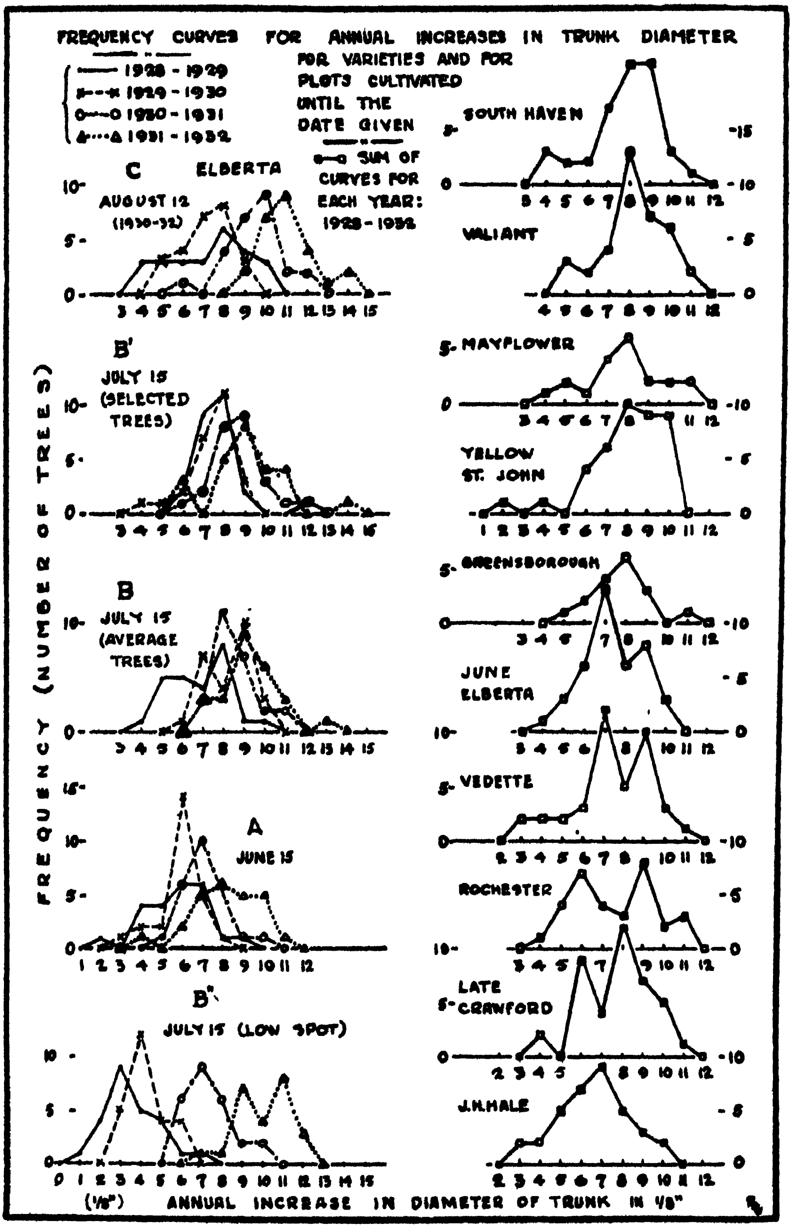


Figure 6. Frequency curves of annual increments in trunk diameter for each year in plots of the Elberta variety cultivated for different lengths of time. For the other varieties, the curves for individual years have been added together.

blight has not been severe in any year since the beginning of the experiment, so that it is impossible to make any statement here as to its control.

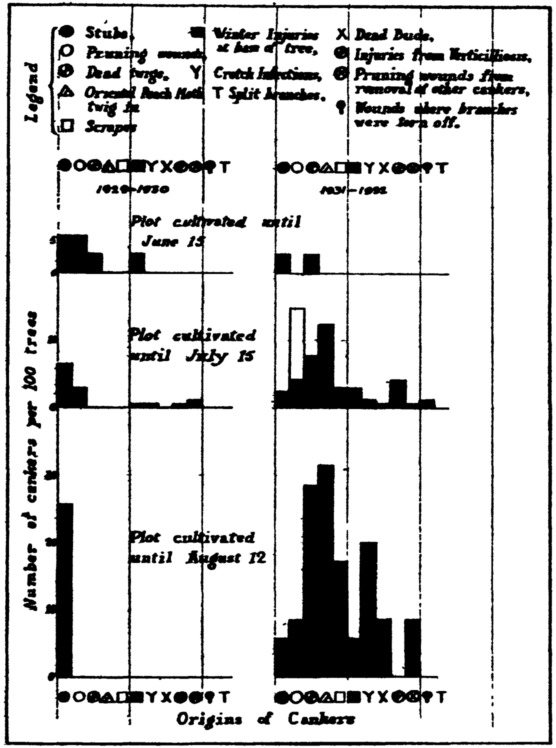
Obviously the control of brown rot of fruit is of major importance commercially, but it is interesting to find that both fruit rot and twig infection can be controlled by the same treatment. In fact because twig lesions generally follow very soon after infection of the fruit with brown rot, the former can be prevented only when the latter is reduced to a minimum. Fortunately, also, most twigs which develop Sclerotinia lesions are so placed that they can easily be removed without damage to the trees. They should be cut out, not only to lessen the possibility of canker but also to reduce the number of possible sources of brown-rot inoculum for the ensuing season.

## Experiments in Cultivation

As it was considered probable that the degree of seasonal maturity attained by peach trees at the beginning of the dormant period might have an important bearing on the canker problem, it was deemed advisable to ascertain the effects of both prolonging and shortening the period of cultivation. Therefore the plot of Elbertas was sub-divided into three sections: A, cultivated until June 15; B, until July 15, and C until August 12. Cover crops were planted on the last day of cultivation. Plots A and B have been carried since 1928 but plot C was begun only in 1930.

The left-hand column of graphs in Figure 6 shows the range and distribution of annual increments in trunk diameter near the soil level of 25 trees in each of the various plots. It will be observed that the annual increase in plot A was from ¾ to 1 inch in the majority of cases, in comparison with 1 to 1⅛ inches in plot B and with 1¼ to 1⅜ inches in plot C during the last two years. (The means for each plot during 1930-1931, and 1931-1932 were: A, 0.92 inches; B, 1.09 inches and C, 1.27 inches). Previous to 1930, the prolonged cultivation was not operative in plot C, and the figures for the first two years were entirely comparable to those for plot B. Figures for plot B are given in three parts, because in addition to average trees, the plot contained a block of trees ($B^1$ Figure 6) especially selected, when planted, for freedom from damage and for good root systems, and a low-lying, poorly-drained area in which the trees were retarded by adverse soil conditions ($B^{11}$ Figure 6). The figures for 1928-29 seem to indicate that the selected trees became established more quickly and uniformly than trees in the rest of the orchard, but in subsequent years they had no apparent advantage over their fellows.

An interesting side light is thrown upon the influence of soil conditions on the peach by comparing the growth rates of the trees in the poorly-drained area before and after the installation of underdrainage. In this area, the location of which is shown enclosed by the dotted line in the lower left hand corner of Figure 1, the mean annual increase in trunk diameter was less than one-half inch during the years 1928-29 and 1929-30 as compared with 0.9 inches for the rest of the plot in the same periods, (see also B, $B^1$ and $B^{11}$ Figure 6). The orchard was underdrained in the fall of 1929. As a result of better drainage the mean annual increment during 1930-31 and 1931-32 for the trees in the "low spot" rose to 1.05 inches in comparison with 1.09 for the remainder. The recovery of the trees in the former is remarkable



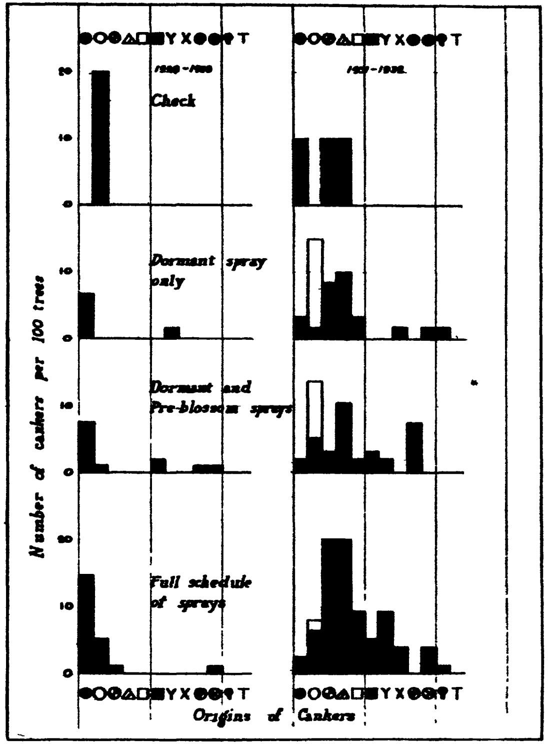


Figure 7 (left). Charts showing the occurrence of cankers of various origins in 1929 and 1930 and in 1931 and 1932 in the plots cultivated for different periods.

Figure 8 (right). Charts showing the occurrence of cankers in the various spray plots in 1929 and 1930 and in 1931 and 1932.

In both Figures 7 and 8 the blank outlines in the pruning wound column represent cankers from disinfected wounds.

especially in view of the fact that the response of the trees in the better drained parts of the plot B was comparatively slight.

The increase in the growth of the trunks with the greater length of the cultivation period is indicative of a corresponding increase in the time during which the trees were growing and therefore of a retardation of seasonal maturity. This was confirmed by observations on the foliage and buds. In August 1929 and 1930, the foliage in plot A took on a light yellowish green color, no new leaves were being produced and buds were well formed. At the same time the foliage of the rest of the orchard remained a deep green, besprinkled with the fresh lighter green of new leaves, while the buds were beginning to form. During the summers of 1931 and 1932, there was more rainfall than in the two previous years, so that the differences in foliage were not conspicuous, though, as before, new growth ceased and bud formation commenced earlier in the plots with the shorter periods of cultivation.

Some evidence of the adverse effects of prolonged cultivation was furnished by the relative prevalence of winter injury in plots A and B in the spring of 1930 when 22.4% of the trees in the whole orchard were damaged at the collar. Injury occurred, for the most part, on the west and south-west sides of the trees, though no side was entirely immune. In plot B, 25.3% of the trees were affected, but only 10% of those in plot A. Incidentally the damaged trees in the latter were on outside rows adjacent to B or to the varieties. Plot C at that time was non-existent. It may also be of interest that the majority of the trees killed by winter injury in 1930 were in the poorly-drained area.

A consideration of the incidence of cankers in these plots discloses a remarkable correlation with the condition of the trees at the beginning of the dormant period (Figure 7). The numbers of cankers appearing in the three plots during 1929 and 1930 were of the same order of magnitude, so that any differences can be attributed to chance. It so happened that plot A had then the largest number of cankers from "die-back" twigs and from winter injury, while the cankers in C all originated from stubs.

The situation became reversed, however, in 1931 and 1932 when the number of cankers per hundred trees rose from 5.8 in plot A, to 50.6 in plot B and to 134.4 in plot C. It would seem that the differences between these figures are too great to be merely coincidental, especially when the greatest increases occurred in those cankers whose origins may be associated with either succulence, seasonal maturity or vigour, namely: dead twigs, peach moth injuries, dead buds, crotches and winter injury at the collar. The larger number of cankers from implement injuries in C may be explained on the basis of the relative immaturity of callus as well as by the greater possibility of injury afforded by the larger trees. A similar explanation accounts for the increased number of cankers from stubs and pruning wounds. Crotch cankers affected 20% of the trees in C, but the damage to crotches in this plot was not confined to canker alone, for an additional 20% of the trees split either slightly or severely during the summer of 1932. On the other hand, splitting and cankering at the crotch was negligible in plot B and absent in plot A although weak crotches were fairly evenly distributed over all plots.

## EXPERIMENTS IN PRUNING

Pruning wounds and stubs evidently play such a considerable rôle in the initiation of cankers, that any investigations on this disease are not complete without experiments in pruning. As the relative importance of these types of pruning cuts has already been commented upon, attention here is directed mainly to the time of pruning and to the effects of disinfection on the resulting wounds. Varieties other than Elberta were pruned towards the end of the dormant season. Pruning was done in rows 1, 2, 8, 9, 10 (Figure 1) of the Elbertas during the dormant season, and in rows 3 to 7 at intervals during the summer. In rows 2 and 3 all pruning cuts were disinfected as follows: trees 9 to 14 with white lead made into a thin paste with boiled linseed oil; trees 12 to 20, with neutrum tar; trees 21 to 26, with corrosive sublimate 1:500, and trees 27 to 32 with 5% Agrisol.[4] In addition a few wounds were treated with a 10% solution of zinc chloride in 25% methyl alcohol.

The time of year at which pruning is conducted has a marked effect upon the rate of healing and therefore on the probability of canker formation. Generally speaking, pruning cuts made in the winter time do not heal so rapidly as those made in the late spring and early summer. If wounds are incurred during the dormant season there is necessarily a delay until spring before the healing processes begin. This means the occurrence of a certain amount of drying out and killing of the living tissue surrounding the wound. The resulting dead tissue is favourable to invasion by canker. The earlier in the dormant season the wound is made, the more the drying out and the longer the exposure to the possibility of infection. On the other hand, during the growing season, healing commences almost as soon as the wound is made, wound periderm is soon formed and callus is produced rapidly, especially during May and June. Later in the growing season, growth is slower. Consequently wounds made, for example in August, do not heal so quickly and the majority go into the dormant season only partly overgrown with callus. Observations showed that if trees were pruned in May or June, wounds were closed as soon as, and often sooner than, wounds made even as late as March. If pruning was done in December or January a larger percentage of the wounds were still open by the following October, by which time, most of the wounds made in March, April, May or June were healed. The following examples may be given to illustrate the relation of the time of pruning to canker formation. Of the pruning wounds of March, 1930, which were not healed by fall, 1.5% became cankered in the spring of 1931, in contrast to 0.2% of unhealed wounds made in May, June and July 1930. The fact that infection by canker-producing organisms is achieved more readily during the late fall, winter and early spring lends support to the view that wounds made during the dormant season are more subject to canker.

Pruning cuts involving the removal of leaders have proved to be more readily cankered than those by which laterals were cut off, although cankers have resulted from both types. This was especially true during the first year when most of the cankers made their appearance at cuts at the top of whips. As it is possible for a canker in this location to affect much of the top of the tree in later years, great care should be exercised in pruning a newly planted orchard. It should be emphasized that although pruning cuts give rise to a certain percentage of cankers in an orchard of any age, they are responsible for the vast majority of cankers appearing in the first year or two.

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[4] Agrisol is a trade name for an English creosote preparation.

Up to the present the disinfection of pruning wounds has not been entirely satisfactory. Zinc chloride, white paint, tar thinned with xylol, have been applied to various wounds with disastrous results, as may be seen in row 2 (Figure 1). White lead paste, without turpentine or excess oil, and unthinned tar were only slightly toxic. Mercuric chloride 1:500 and 5% Agrisol did not injure exposed tissue, but their effectiveness is probably short lived on account of leaching by rain. Even where disinfectants were non-toxic to the tree, disinfected wounds have not healed any more readily than untreated ones. In any case, when pruning wounds are properly made the percentage resulting in cankers is negligible, so that the benefits which might be derived from the disinfection of ordinary pruning cuts are likely to be small. However, it might be worth while to treat large wounds, which would normally require several years to heal over. Disinfectants which are toxic to the living tissues of the trees should not be used even on large wounds unless the vulnerable parts are first covered with some protective substance.

## PREVENTIVE MEASURES

While it may not be possible to keep an orchard entirely free from canker, it should not be difficult to reduce the number of new cankers. A few control measures, suggested by a consideration of the factors already outlined in this paper, are briefly given as follows.

1. It has already been pointed out that the earlier in the dormant season that wounds are made, the greater is the probability of canker formation. The early part of the growing season is the best time to prune peaches, but as pruning at that time may not be practicable in commercial orchards, it should be deferred as late as possible in the spring, say until late March or April or even later. The making of close pruning wounds should also be emphasized as the stub is both undesirable and dangerous. Particular care in pruning is required during the first few years after setting out.

2. Remove all dead wood at pruning time. It is also worth while to make an inspection of the orchards late in June to take out any dead wood which was missed in pruning or which may have developed in the meantime.

3. Burn as soon as possible all dead wood and brush removed during pruning.

4. Avoid any cultural practices, such as cultivation beyond the first week in July, which will over-stimulate growth or send the trees into the dormant season in an immature condition. For the same reason, do not apply fertilizers after the early part of May. The short period of cultivation not only tends to reduce the occurrence of cankers, but is also a good horticultural practice. It is equally desirable to keep the trees in a thriving condition.

5. Avoid injury to the trees during cultivation, spraying and picking. Broken branches should be removed as soon as possible.

6. Remove and destroy during pruning all cankers on small branches and twigs. Cut them out at least a foot below the visible canker if possible.

7. Clean out in late spring cankers which cannot be removed and which are located at crucial points, and keep them free from gum.

8. Large wounds and cankers, after cleaning, may be disinfected with mercuric chloride 1:500 and covered with a protective such as white lead paste free from turpentine and with no excess of oil.

9. Spray during the summer months with a wettable sulphur, or dust with sulphur to control brown rot. Incidentally summer spraying also controls scab or ink-spot.

10. Remove rotted fruits from the trees in the fall and plough under or otherwise destroy them.

## SUMMARY

1. Cankers on the peach originate from wounds or dead areas such as: dead twigs, twigs injured by Oriental peach moths, stubs, pruning wounds, implement scrapes, damaged crotches, winter injuries at the collar, pruning wounds resulting from the removal of previous cankers, injuries following *Verticillium* wilt, dead buds, and broken or split branches. The relative importance of each of these points of origin is discussed.

2. Brown rot is of significance in the canker problem chiefly because it causes twig lesions which may serve as foci of infection for canker-producing organisms.

3. Cankers do not appear to be controlled by spraying.

4. Adequate spraying controls brown rot of fruit and twig lesions associated therewith.

5. Trees which are over stimulated by certain cultural practices and which are not seasonally mature at leaf fall are more subject to canker than thrifty trees which are properly matured.

6. There is some evidence of differences in varietal susceptibility to canker.

7. Pruning wounds made in the dormant season and stubs are cankered more frequently than pruning wounds made in the early growing season. Proper pruning practices are necessary in orchards of any age and especially so in newly planted ones.

8. Disinfection is valuable mainly in the case of large wounds.

9. A number of suggestions for prevention of canker have been enumerated.

Thanks are due to Dr. G. H. Berkeley for helpful suggestions and criticisms throughout the course of the investigations.

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## CURRENT PUBLICATIONS

APPLE POLLINATION STUDIES IN THE ANNAPOLIS VALLEY, N.S. Under the Direction of W. H. Brittain. Bulletin No. 162, Dominion Department of Agriculture.

Apple Pollination Studies in the Annapolis Valley, Nova Scotia, represents the most comprehensive study of apple pollination so far attempted. In addition to a popular summary the bulletin consists of five main sections: (1) Introduction, discussing the general features of the apple industry in Nova Scotia having a particular bearing on the problem, together with a brief resume of factors other than pollination affecting fruit production; (2) Pollination and fruitfulness in apples in which the pollination problem in its various phases is outlined; (3) Experimental studies in apple pollination in which the exhaustive experiments undertaken in all phases of the problem are explained and the results concisely summarized; (4) Field studies in insect pollinators, in which the rôle of wild insect pollinators is explained and the problems connected with the utilization of hive bees are elucidated; (5) Studies in bee poisoning in which the results of experimental work undertaken to determine the cause and prevention of poisoning among bees due to spraying and dusting practice is fully set forth.

Though the work deals with experiments undertaken in Nova Scotia, an attempt has been made to attack the problem from a fundamental standpoint so that the results obtained are, to a large extent, applicable wherever apples are grown. It is shown that a pollination problem arises; (1) when self-unfruitful varieties, which includes practically all commercial sorts, are planted in solid blocks; (2) when cross-unfruitful varieties are planted together; and (3) when the population of pollination insects is inadequate to effect pollination. An important point that is clearly brought out in the studies is that apple varieties may be sharply divided into two groups, namely, good pollinizers and poor pollinizers. The first of these are suitable for pollination of others blossoming at the same time, the second are of inferior value or worthless for all other varieties. In the light of the foregoing the proper planting of orchards to secure adequate pollination is discussed and illustrated.

The work of wild and hive bees in pollinating orchards is fully discussed. The former were found to be more widely distributed than formerly disposed. The necessity of supplying hive bees to insure pollination in certain circumstances is explained and the proper method of distribution and placing is discussed. A full discussion of the factors resulting in bee poisoning is included, with methods of avoiding or minimizing such damage. The bulletin concludes with a list of literature cited and an excellent index.

While the bulletin is a technical one, a popular summary placed in the front sets forth in brief form the practical results of the investigation and this together with the charts, diagrams and figures with which it is profusely illustrated, will enable it to be used by the practical grower. Copies are available on application to the Publications Branch, Dominion Department of Agriculture, Ottawa.

# AWNED HOODS IN BARLEY

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[Received for publication January 14, 1933]

During a visit to China in 1929, Professor H. H. Love, of Cornell University, found at Kweiteh, Honan, a barley plant with unusual awns. Borne on the awns about halfway from the base to the tip was a structure resembling a hood, while the portion of the awn above the hood was variously flexed, giving the head a curly appearance. Later observation showed that this "curly" barley was distributed fairly widely throughout the plains region of Honan Province, occurring as an impurity in fields of normally awned barley. It had been grown experimentally at Kaifeng, Honan, where it bred true for the "curly" character.

Its intermediacy of form, and the circumstance that both awned and hooded barleys occur commonly where the intermediate form was found suggested that "curly" barley may have originated as a natural cross. On the other hand, any theory of the origin of this form must take account of its frequent occurrence (scatteringly present in about 5% of the barley fields near Kweiteh) and its genetic stability.

Biffen (*1*) used the terms "supernumerary floret" and "flowerless awn" in describing hooded and straight-awned types. "On crossing these hooded varieties with those bearing normal, i.e., flowerless awns, the hybrids in all cases are hooded, the supernumerary floret being borne either on the apex of the palea or on an awn from a half to two inches in length". In a later paper (*2*) he records some of his $F_2$ and $F_3$ results: "In the $F_2$ generation . . . there was considerable variation in the length of the awns carrying the supernumerary flowers, but no indications could be detected of segregation into individuals with sessile hoods, awned hoods, and true awns only". And further, out of 45 hooded $F_2$ progenies tested in $F_3$, "six individuals with hoods borne on awns of two or more inches in length from *H. Abyssinicum* × *trifurcatum* which were tested, all bred true to this character . . . The permanence of this feature suggestive of a blend of the parent characteristics was not expected, and no explanations can yet be offered to account for it".

G. von Ubisch (*3*) also discussed the genetics of awned and hooded barleys, assuming four factor pairs in interpreting her results:

> Factors A and K together give hoods which are reduced, but not wholly suppressed, in the presence of factor S.
>
> S is dominant over A and K singly; AAkkSS and aaKKSS are therefore awnless.
>
> Awns are of the constitutions AAkkss, aaKKss, and aakkss, and are long in the presence of factor I, short when I is absent.
>
> We have therefore hoods of the forms AAKKSS and AAKKss, but the former are, as we have said, much reduced, while our ordinary hoods are all AAKKss.

---

[1] Graduate Assistant.

An elaboration of the interaction of the factors thus proposed gives the following theoretical $F_2$ ratio:

| | |
|---|---|
| Reduced hoods | 81 |
| Ordinary hoods | 27 |
| Long awn | 9 |
| Short awn | 28 |
| Awnless | 111 |
| Total | 256 |

It is apparent that in this scheme one individual out of 81 (or more or less if the proportions are modified by linkage) will be homozygous, and will have the formula AAKKIISS. This, then, would be the true-breeding awn-hooded form for which Biffen has no explanation to offer. It is true that Biffen's true-breeding progenies were apparently derived from six individuals out of 45; but Biffen does not state the relation of these six individuals to his total population, and it seems possible that they all came from a single homozygous $F_2$ plant.

These results provide a possible basis for the hybrid origin of the "curly" barley of Honan. The necessary assumptions in this case are the natural crossing of awned and hooded barley and the persistence of a homozygous segregate. There is no indication that either artificial hybridization or artificial selection has played any part in the establishment and distribution of "curly" barley as suggested in this paper.

## SUMMARY

A barley occurring under field conditions in China is found to resemble a true-breeding progeny of hybrid origin reported by Biffen in 1907.

This barley is intermediate between awned and hooded.

The relations between awns and hoods proposed by von Ubisch in 1923 suggest a possible explanation of this resemblance, and of the origin of the form found in China.

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# A PRELIMINARY NOTE ON AN UNREPORTED ROOTROT OF OATS[1]

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[Received for publication September 12, 1933]

A serious rootrot of oats, which has been under my observation, developed in a wide area in the Edmonton district, during the crop season of 1933. Although the distribution, symptoms and etiology of the disease are not yet fully understood, sufficient information is available now to briefly describe its general appearance for those who might be able to recognize it elsewhere.

Approximately 50 fields of oats near Edmonton were examined and evidence of this rootrot was found in each field, and in many cases the loss was very marked. Apparently this rootrot may appear in local or in general areas, or on single plants, at any time during the crop season. In the field, the symptoms are most marked on plants from four to eight weeks old, and especially so before the crown root system appears.

The lower leaves of affected plants droop, turn light brown to reddish and slowly wither. Such plants assume an upright condition, with rather narrow leaves and reduced foliage, and are stunted and chlorotic, according to the severity of the attack. The general above-ground appearance of these plants in the field and in the greenhouse is indicated in Figure 1, A. In spite of an advanced blighted condition, affected plants tend to recover when the crown roots develop, but the emergence of the panicle from the sheath may be delayed and its size and number of spikelets definitely reduced. Diseased plants commonly have one tiller, in contrast to healthy plants, which may produce more. Another symptom, both in field and greenhouse, is the tendency of the lower part of the culms between the nodes, and also the nodes of affected plants, to develop a reddish to mauve pigment. With the latter exception, the general above-ground symptoms are somewhat similar to the effects produced by "browning" rootrot of cereals, described by Vanterpool and Ledingham (*1*).

The effect on the part of the plant below ground is also fairly definite. The primary roots are greatly reduced from normal development. These, and the sub-crown internode, commonly become straw-colored, but rarely darker until later. The crown itself appears to remain bright colored and normal for some time. The roots from the crown area may be attacked also. On the primary roots, the sub-crown internode, and sometimes above the crown later, may be seen minute dark sclerotia-like bodies, barely visible to the naked eye. These are illustrated in Figure 1, B. When magnified, on natural or stained tissue, these bodies are seen to be firmly attached by hyphae to the host. Cultured, these minute masses rather consistently yield a fungus, the aerial hyphae of which is cream to white colored, and which, during early growth, stains potato dextrose agar yellow. Although the pathogenicity of this fungus has not yet been established, its constant association with the disease would suggest that it causes the symptoms described.

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[1] A contribution from the Division of Botany, Experimental Farms Branch, Department of Agriculture, Ottawa, Canada, co-operating with the University of Alberta.
[2] Plant Pathologist in Charge.

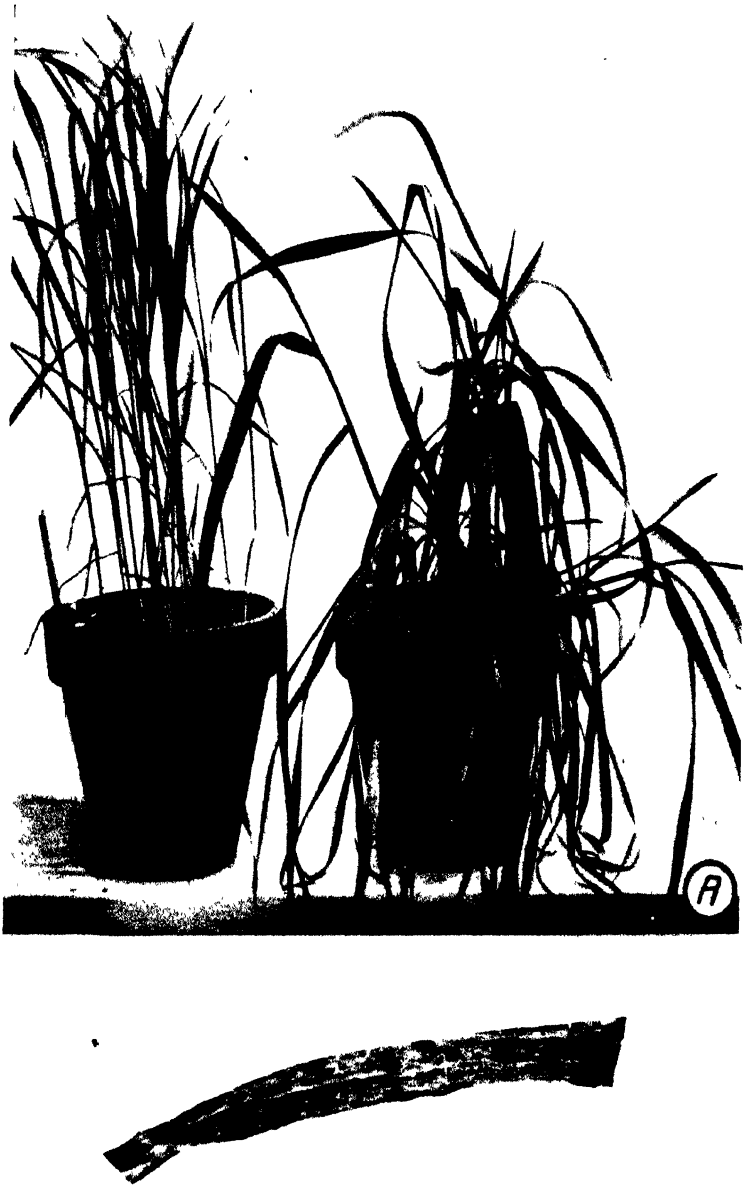

FIGURE 1.

A. Left: stunted plants grown in greenhouse in soil from unhealthy field. Note upright condition, dead lower leaves, narrow foliage, and coloring of lower portion of culms.

B. Dark fungal masses typical of those on the sub-crown internodes and primary roots of stunted plants.

Dr. G. R. Bisby, University of Manitoba, who kindly examined a culture, reported tentatively as, "I would say that the sporulating fungus is a *Gliocladium*, probably *G. roseum*". Field symptoms were reproduced on oats grown in infested soil in the greenhouse, while the same soil sterilized, and also other soil, apparently healthy, unsterilized, yielded normal plants. A more complete account of this malady will be available shortly.

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1. Vanterpool, T. C., and G. A. Ledingham. Studies on "browning" rootrot of cereals. Can. Jour. Res. *2:* 171-194. 1930.

# CURRENT PUBLICATIONS

## STERILIZATION OF NARCISSUS BULBS BY IMMERSION IN SILVER NITRATE-POTASSIUM CYANIDE SOLUTION IN VACUO.

W. Newton, R. J. Hastings and J. E. Bosher. Canadian Journal of Research *9*: 31-36. July 1933.

Through the use of a dye solution, evidence was obtained that a liquid disinfectant may be forced into the narcissus bulb parts invaded by nematodes and fly larvae by immersion *in vacuo*. An investigation of the lethal properties of solutions against nematodes and their influence upon bulb growth led to the selection of a silver nitrate solution as a promising disinfectant, but owing to instability of silver nitrate in the presence of chlorides and other substances in tap water and in dirt clinging to bulbs, its use had no commercial possibilities. However when silver salt was combined with potassium cyanide in the ratio of 1 to 3 by weight, an effective solution of satisfactory stability was obtained. A solution of silver nitrate 0.05% and potassium cyanide 0.15% by weight, forced into narcissus bulbs by an evacuation process, effectively destroyed bulb nematodes and bulb fly larvae without significant injury to bulb growth under greenhouse conditions. Field tests with bulbs treated in silver nitrate-potassium cyanide solutions resulted in the reduction of infection from 26.8 to 1%, a 96% control, and no evidence of injury in the foliage or bloom was detected.

# RESUME DES ARTICLES PUBLIES EN ANGLAIS DANS CE NUMERO

**L'AVENIR DE LA SCIENCE AGRICOLE.** Sir A. Daniel Hall, Directeur, John Innis Horticultural Institute, Londres, Angleterre.

Le développement considérable de la spécialisation en science agricole est discuté par l'auteur qui fait ressortir la difficulté qu'il y a à maintenir en contact avec le côté pratique de l'agriculture les savants occupés à des travaux de recherches hautement spécialisés. L'auteur recommande que chaque technicien s'occupant de recherche ait constamment à résoudre quelque problème d'ordre pratique en plus de son principal travail de recherche. Le problème de la santé des animaux devrait être envisagé beaucoup plus au point de vue de la prévention des maladies au moyen d'une nutrition convenable et de soins généraux qu'au point de vue de la guérison des maladies. Le temps est venu où notre connaissance des principes de la génétique que nous ont appris la sélection des plantes et l'élevage des petits animaux devrait êrre employée à la création de races spécialisées de nos principaux animaux domestiques. En raison de son coût, pareil travail devrait être entrepris sur une base coopérative par plusieurs centaines de fermiers sous la direction d'un expert. Des recherches d'ordre économique s'imposent en agriculture. L'auteur pense que les améliorations dans la pratique agricole que peuvent apporter les recherches agronomiques ne sont pas suffisantes pour contrebalancer le sévère handicap économique auquel est sujet le fermier isolé du type paysan. L'auteur préconise l'organisation des cultivateurs en vue de la production et de la vente organisées.

**INFLUENCE DES INSECTES SUR DE DEVELOPPEMENT DES FORETS.** J. M. Swaine, Service fédéral d'entomologie, Ottawa, Ont.

L'auteur fait ressortir le changement dans la composition des forêts qui s'est produit depuis la colonisation du Canada. Depuis cette période les insectes ont détruit environ trois fois autant d'arbres que le feu. L'auteur discute les déprédations de certaines espèces et les relations entre les insectes et le milieu forestier. Il est désirable que des recherches de nature coopérative soient entreprises entre les différentes sciences qu'intéresse la question.

**RECHERCHES SUR LE CHANCRE DU PECHER.** R. S. Willison, Laboratoire fédéral de pathologie végétale, St. Catharines, Ont.

Le chancre du pêcher a son origine dans des parties de l'arbre blessées ou mortes telles que rameaux ou bourgeons morts, blessures de taille, blessures résultant d'attaques par des insectes ou des cryptogammes. L'importance relative de ces différents points d'origine est discutée par l'auteur. La pourriture brune est importante dans le problème du chancre parce qu'elle produit des lésions dans les rameaux qui servent ensuite de foyer d'infection aux organismes producteurs du chancre. Le chancre ne semble pas être contrôlé par des pulvérisations mais celles-ci peuvent contrôler la pourriture brune du fruit et prévenir les lésions des rameaux qui en résultent. Les arbres trop stimulés par certaines pratiques culturales et qui ne sont pas convenablement aoûtés sont plus sensibles que les autres aux attaques de chancre. Les diverses variétés semblent avoir des susceptibilités différentes. Les blessures de taille faites pendant le saison de repos semblent se chancrer plus facilement que celles faites au début de la période de croissance. La désinfection des blessures présente de l'intérêt surtout pour les blessures les plus grandes.

**ORGE A CAPUCHON BARBU.** Rundall M. Lewis, Université de Toronto, Toronto, Ont.

L'auteur discute la ressemblance entre une orge sauvage trouvée en Chine et une orge d'origine hybride signalée par Biffen en 1907.

**Note preliminaire sur une Pourriture des Racines de l'Avoine.** G. B. Sanford, Laboratoire fédéral de pathologie Végétale, Université de l'Alberta, Edmonton, Alberta.

L'auteur décrit une pourriture des racines de l'avoine jusqu'ici non signalée et qui semble associée à la présence d'un champignon, probablement *Gliocladium roseum.*

## NOUVELLES

Les membres de la C.S.T.A. ont appris aves plaisir la nomination de M. P. Nolasque April (Laval '15) au poste de Directeur de la nouvelle Ecole d'Agriculture de Ste-Martine, P.Q. Bonne chance et bon succès au nouveau Directeur.

J. R. Pelletier (Laval '27), autrefois assistant-regisseur à la Station Expérimentale de Farnham, a été transferré à la Station Expérimentale de Ste-Anne de la Pocatière comme assistant-regisseur.

# NOTES AND NEWS

## BEGINNING VOLUME XIV

The current issue of *Scientific Agriculture* is the first number in Volume XIV. There will be no change in editorial policy, but we will strive to improve constantly. It is an exceedingly difficult task to satisfy all subscribers continually, as the limits of space prevent the inclusion of enough articles each month to appeal to the varied interests of all. We will continue to attempt to include at least one item a month which should have a fairly wide appeal. In this issue, everyone should read Sir Daniel Hall's analysis of the future of agricultural reaserch. It was spoken of at Regina as one of the best addresses ever delivered to the Society. Sir Daniel Hall was head of the British delegation to the World's Grain Exhibition and Conference and is recognized as one of the outstanding agricultural leaders of the world. Another article which is of wider interest than usual is Dr. J. M. Swaine's address on forest insect activities. Dr. Swaine, Associate Domininon Entomologist, was honoured by an invitation from the Entomological Society of America to give the annual address at the Atlantic City meeting last December. While very few technical agriculturists are closely connected with forestry, most of us have a love for the forests and are interested in their conservation. Some day we may find forestry much more closely connected with agriculture than at present. Dr. Swaine's paper is an excellent summary of the insect situation and well worth reading as a matter of national importance.

# NOTES AND NEWS

## J. K. KING, DEPUTY MINISTER FOR NEW BRUNSWICK

The appointment of Mr. J. K. King as Deputy Minister of Agriculture for the Province of New Brunswick has recently been announced. Mr. King, who is a native of Sussex, New Brunswick, graduated from Macdonald College in 1913. For three years he was District Depresentative for Pontiac County, P.Q. From 1916 to 1927 he was District Sheep and Swine Promotor for New Brunswick, from which position he resigned to become Manager of the Maritime Marketing Board. In 1928 he came to Montreal as Secretary of the Canadian Live Stock Co-operative, and since 1932 has been associated with the Co-operative Federee of Quebec.

Mr. King enters upon his new duties with a sound knowledge of the agricultural problems of New Brunswick, and a speaking acquaintance with hundreds of farmers throughout the province. Having had the benefit of experience in the federal department and in commercial life he has a good understanding of the necessity of co-ordinating the extension activities of provincial services with those of other departments and organizations. In a rpovince where the agricultural staff is not large and at a time when curtailment is taking place in various services, both federal and provincial, unified action is necessary. Mr. King's experience and tact will be a great asset to the New Brunswick Department in carrying on existing services and in widening its activities as conditions permit.

## DOMINION LIVE STOCK BRANCH REORGANIZATION

As announced in the August issue of *Scientific Agriculture* the separate Divisions which existed in the Dominion Live Stock Branch have disappeared to be followed by two sections known as Services—Live Stock Field Services and Live Stock Market Services.

Mr. R. S. Hamer, formerly Chief of the Cattle Division, becomes Assistant Live Stock Commissioner and Chief of Field Services. Mr. A. McMillan becomes Associate Chief in charge of Sheep and Wool Services. Mr. A. W. Peterson is Assistant Chief in charge of Cattle and Swine, and Mr. F. G. Semple is Assistant to Chief. Mr. C. S. Wood remains Chief Inspector of the Record of Performance for Cattle and Mr. W. L. Graham remains Supervisor of Cow-Testing. The field services in each province have been placed under the direction of the following men:

T. B. Stewart, British Columbia.
John Norquay, Alberta.
F. C. Whiting, Saskatchewan.
Dr. A. S. Morrison, Manitoba.
S. Boily, Quebec.
J. H. King, New Brunswick.
J. A. Steele, Nova Scotia.
S. D. Irvine, Prince Edward Island.

Ontario will be administered from headquarters at Ottawa.

Mr. W. J. McCallum, formerly Chief of the Stockyards Service becomes Chief of the Market Services. An Assistant to Chief with experience in horses remains to be appointed. Mr. P. E. Light retains charge of the Markets Intelligence Service as Markets Analyst and Editor. Mr. W. A. Brown remains as Chief of Poultry Services, with S. C. Barry, Assistant Chief and E. D. Bonyman, Chief Market Poultry Inspector. Mr. R. W. Zavitz as Chief Poultry Inspector retains charge of R.O.P. for Poultry and of Hatchery Approval.

# REORGANIZATION AT MANITOBA AGRICULTURAL COLLEGE

## DR. A. SAVAGE APPOINTED DEAN

Reorganization of the staff of the University of Manitoba has recently taken place. The necessity for economy, arising out of the unfortunate financial situation which prevails, has made it necessary to eliminate positions wherever possible. The elimination of the purely administrative office of Dean has brought about the retirement of Dean W. C. McKillican.

The new Dean, Dr. Alfred Savage, was born in Montreal and graduated from Macdonald College in 1911. From 1911 to 1914 he attended Cornell University where he received the degree of D.V.M. During the war he served in the Canadian Army Veterinary Corp, returning to Macdonald College to hold the position of Veterinarian from 1919-21. Since 1921 he has held the position of Professor of Animal Pathology in the University of Manitoba. He took post graduate work at the Royal Veterinary College at Edinburgh during 1927-28 and is a member of the Royal College of Veterinary Surgeons.

Dean Savage is widely known as one of the outstanding animal pathologists in Canada. He has many research papers to his credit and is a member of several American and Canadian scientific societies. In addition to holding the respect of his colleagues in veterinary circles, he is regarded by technicians generally as a thorough scientist, and by farmers as a sound agriculturist. The fact that he has been chosen to head the Faculty of Agriculture at such a critical time in the history of the University places a heavy responsibility on his shoulders. Those who know him realize that Dean Savage will give vigorous leadership in the present crisis. He will retain his teaching position in addition to handling the administrative duties of Dean of the Faculty of Agriculture and Home Economics. The following will make up the staff under his direction for the year 1933-34.

### AGRICULTURAL STAFF, UNIVERSITY OF MANITOBA

A. Savage, Professor of Bacteriology and Animal Pathology.
F. W. Broderick, Professor of Horticulture and Forestry.
M. C. Herner, Professor of Poultry Husbandry.
G. W. Wood, Professor of Animal Husbandry.
R. W. Brown, Professor of Dairy Husbandry.
G. P. McRostie, Professor of Agronomy.
A. V. Mitchener, Professor of Entomology.
J. McC. Brown, Associate Professor of Animal Husbandry.
J. H. Ellis, Associate Professor of Agronomy.
N. James, Assistant Professor of Bacteriology.
M. C. Jamieson, Lecturer in Bacteriology.

### HOME ECONOMICS STAFF, UNIVERSITY OF MANITOBA

Mrs. L. C. Duncan, Director of Home Economics.
Miss M. C. Hiltz, Assistant Professor of Nutrition.
Mrs. J. South, Lecturer in Household Art.
Miss C. L. Groff, Lecturer in Clothing and Textiles.
Miss E. G. McFadden, Lecturer in Clothing and Textiles.
Miss M. C. Moxon, Lecturer in Education.
Miss F. E. M. McLauchlin, Lecturer in Nutrition.
Miss L. Panton, Instructor in Institutional Management.

In addition to the staff listed, the following members of other Faculties will be concerned with Agricultural and Home Economics students:

M. A. Parker, Professor of Chemistry.
W. F. Geddes, Professor of Chemistry.
W. A. Anderson, Lecturer in Physics.
V. W. Jackson, Professor of Zoology.
G. R. Bisby, Professor of Botany.
C. R. Hopper, Associate Professor of English.
H. C. Grant, Associate Professor of Agricultural Economics.
G. L. Shanks, Associate Professor of Civil Engineering.
R. W. Youmans, Physical Instructor.

## NEWS ITEMS

N. A. MacRae (Queen's '28), Tobacco Division, Central Experimental Farm, Ottawa, has recently been made a Fellow of the American Association for the Advancement of Science.

H. Groh (Toronto, '08), Botanist, Central Experimental Farm, Ottawa, was married on September 16th to Miss Mildred M. Krupp of Amyot, Ontario.

F. H. Peto (Manitoba, '28), Division of Biology and Agriculture, National Research Laboratories, Ottawa, was married on September 9th to Miss Ruth Beverley Robertson of Edmonton, Alberta.

K. W. Neatby (Saskatchewan '24), has received a National Research Fellowship and is studying under Sir R. H. Biffen at the School of Agriculture, Cambridge, England.

E. G. Booth (Saskatchewan '21), is now Chief of the Applications and New Business Division, Federal Land Bank of St. Paul. His home address is 1767 Bayard Ave., St. Paul, Minn.

J. F. Booth (Saskatchewan '19), Commissioner of the Agricultural Economics Branch, Dominion Department of Agriculture, Ottawa, has been invited to spend three years in India as economic advisor on agriculture to the Imperial Government. The request for Dr. Booth's services was formally transmitted through the British Government to the Canadian Government. The Dominion Department of Agriculture felt that his services could not be spared, and Dr. Booth will remain in charge of his department. This is fortunate, as work for this Branch of the Dominion Department of Agriculture is increasing rapidly, especially along the line of co-operative effort with other branches and with provincial departments and institutions. During the last two years Dr. Booth has represented agricultural economics on several interdepartmental committees including committees of the Inperial Economic Conference in 1932, and it is most desirable that his services should continue to be available to Canadian agriculture.

W. B. Gornall (Nova Scotia '09), Assistant to Dominion Fruit Commissioner, Ottawa, has been transferred from the Department of Agriculture to the position of Fruit Commissioner to Great Britain under the Department of Trade and Commerce. He will take up his new position in London shortly, where he will do investigational work in the interests of the Canadian fruit industry. For the past three years he has been chief of the markets division in the Fruit Branch. He had practical experience in fruit farming in the Annapolis Valley of Nova Scotia previous to entering the government service. Mr. Gornall was born in England and served with the Imperial forces during the Great War. His many friends in Canada, while regretting his departure to England, congratulate him on his appointment to this important post.

SCIENTIFIC AGRICULTURE

Vol. XIV OCTOBER, 1933 No. 2

# THE EFFECT OF SOME COMMERCIAL FERTILIZERS ON THE BOTANICAL COMPOSITION AND YIELD OF PERMANENT PASTURES[1]

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[Received for publication June 22, 1933]

## INTRODUCTION

Comparatively little attention has been devoted hitherto to the study of pastures in this country. From time to time, the introduction of new species has been undertaken with a view to pasture improvement, and pasture management has begun to receive some critical study. There was a change from the extensive to intensive use of pasture lands, and it became necessary to study the reaction of the pasture complex to this system.

Since changes in the pasture types can be achieved by management and control of grazing, an understanding of the influence of the chief factors on yield and botanical composition becomes necessary.

## THE PASTURE PROBLEM

The pastures of the Province of Quebec represented 3,686,100 acres or 20.7% of the total farm land occupied in 1931. For the same year the number of milch cows was 836,000, which means that there were 4.4 acres of pasture per milch cow. It is an additional fact that milch cows depend upon this pasturage for a large part of their sustenance. The average number of days the cows are pastured is 170, so that any improvement or deterioriation of this crop is of prime importance to our country.

The permanent pastures of Quebec may be grouped into three classes according to the methods of treatment: (1) those that can be plowed and re-established; (2) those too steep or rough to make plowing and re-seeding practical but which may be improved by some form of top dressing; (3) those more suitable for timber production than pastures. By far the largest area is occupied by the pastures belonging to the second class. These pastures are rough, having stones, stumps, hardhack and moss, and cannot be profitably improved by plowing and re-seeding. It is on pastures of this type that the experiments described in this paper were planned, in order to obtain information on the improvement of permanent pastures.

The data presented in this thesis were made available through the cooperation of Macdonald College and the Quebec Department of Agriculture.

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[1] Part of a thesis submitted to the Faculty of Graduate Studies and Research of McGill University in partial fulfillment of the requirements for the Degree of Master of Science.

Contribution from the Faculty of Agriculture of McGill University, Macdonald College, P.Q., Canada. Journal Series No. 33.

[2] Formerly Graduate Assistant in the Department of Agronomy, Macdonald College, McGill University, P.Q.

## REVIEW OF LITERATURE

It is not intended in this paper to give a complete review of the literature bearing on pastures, but only of that which bears on the question of the effects of top dressing on the yield and the botanical composition of pastures.

As early as 1854, Flint (*11*) wrote that guano mixed with equal quantity of plaster was found beneficial in top dressing pasture lands. Rothamsted Station in England (*23*) reported on experiments started in 1856 and showed that the fertilizers were found to be very effective in changing the flora and yield of grassland. At Cockle Park, Northumberland County, England (*24*), basic slag was found to be the most beneficial, while nitrate of soda increased the grasses at the expense of clovers. Stapledon and Thomas (*28*) found that upland pastures responded relatively better than the lowland to N P K. Davies and Jones (*9*) showed that complete manurial dressing was the most beneficial, and that phosphorus gave very striking responses. Heavy applications of lime gave significant increases in the yield, while nitrogen has been the one single ingredient which has turned the grass-clover balance in favour of the grasses. Gardner *et al* (*13*), Stapledon (*28*, *29*) Watson *et al* (*32*), and Woodman and Underwood (*34*) have shown that nitrogenous manures in the form of nitro-chalk or sulphate of ammonia increased the yield of pastures and increased the grasses at the expense of clovers. Brenchley (*3*, *4*) studied the effect of lime in pastures at Rothamsted Experimental Station. It was found that a considerable increase was brought about by liming areas receiving artificial manures containing sulphate of ammonia, but that where organic manure was applied with or without artificials the tendency was to decrease the yield. Lime increased the grass species and decreased the weeds.

In United States, Beaumont (*2*) found that lime was the most effective single material in producing desirable changes in the vegetation, while Barnes (*1*), Van Alstine and Cook (*31*), Brown (*6*, *7*), Carrier and Oakley (*8*), Hutcheson and Wolfe (*17*), Mortimer and Richards (*18*), Ohio Station (*21*), Pennsylvania Station (*22*), and Skinner and Knoll (*27*) presented data to show that complete fertilizer was the most effective in increasing the yield and in producing the desirable changes in the flora of pastures. Haskell (*16*) showed that potash was the most effective of any treatments at Massachusetts Station. Odland *et al* (*20*) reported on combinations of fertilizers and showed that single elements were beneficial, but that complete minerals with nitrogen were the best.

In New Zealand, Rigg and Askew (*25*, *26*) found that ammonium sulphate used alone or in combination with either superphosphate or superphosphate and potash gave a relatively high increase in yield of dry matter, and the nitrogen favoured the growth of grasses rather than clovers.

Very favourable results were obtained by Whittet (*33*) in top dressing pastures in New South Wales. Superphosphate increased the yields and produced the desirable changes in the vegetation.

Australian pastures may be improved as shown by Mullett (*19*). Superphosphate was found to be a fundamental necessity though the addition of nitrogenous fertilizer to superphosphate had possibilities.

Foss (*12*) at Volbu Station, Norway, showed that superphosphate doubled the yield and stimulated the clovers. Nitrogen was effective and encouraged the stand of grasses.

Thomas (*30*) and Harcourt *et al* (*15*), reported on co-operative experiments with fertilizers on pastures in Ontario. The results were very satisfactory and showed large increases in yield, due to nitrogen, phosphorus and potash. There was a definite change in the flora due to the application of fertilizers, an increase in grasses and clovers and a decrease in weeds.

Summarizing the literature bearing on the question of top dressing of permanent pastures in general, it may be stated:

(1) Superphosphate showed excellent results on most pastures. An increase in yield and desirable species was obtained.

(2) Potash increased the yields and changed the flora in some pastures, but showed no beneficial effects in others.

(3) Nitrogen gave marked responses in nearly all pastures. There was an increase in the yield, and the botanical composition generally changed in favour of grass species.

(4) Generally, lime alone or in combination with mineral fertilizers, showed good results, though deleterious effects were produced when applied with organic manures.

## LOCATION AND PLAN OF EXPERIMENT

Permanent pastures were selected in the Quebec eastern townships, in the vicinity of Cowansville, and as far as possible, similar types were taken. These were laid out to measure the influence of the three common fertilizers,—nitrogen, phosphorus and potassium, alone and in combination, and also with and without lime.

The treatments on the plots were as follows:—Ca N P K, Ca P K, Ca, Ca P, Ca K, N P K, P K, Nil, P, and K.

In October, 1930, six such areas were laid out on the farms of Messrs. W. R. Beach, W. E. Dryden, W. W. Mason, F. H. Pickle, A. Robertson and C. Sweet; these experiments will be referred to as Series I. In October, 1931, four more similar areas were laid out on the farms of Messrs. G. A. Doherty, P. V. Hawke, R. R. Mason, and M. Miller; these experiments will be referred to as Series II.

The soils of Series I and Series II are typical brown forest soils, with the exception of W. E. Dryden's (Series I) which has a deeper layer of undecomposed organic matter at the surface and approaches a muck swamp condition. In general this "brown forest" soil profile may be described as follows: A horizon—6 to 10 inches deep, medium brown in colour, having an even distribution of minerals, is loosely packed, fine, sandy loam, high in organic matter; B horizon—12 to 18 inches deep, medium to light yellowish brown in colour, is usually loosely packed, fine to coarse sandy loam, containing much less organic matter than A horizon; C horizon is a little lighter in colour than B horizon, is compacted coarse sandy or gravelly soil, low in organic matter.

The chemical analyses of the soils taken from the untreated areas in each series had the following average percentage figures for the surface and subsoil samples respectively:—pH value - 6.04, 6.22; lime requirement in pounds CaO per acre - 1583, 1266; nitrate nitrogen p.p.m. fresh soil - 20.57, 5.75; moisture when taken - 33.23, 25.75; hygroscopic moisture - 3.21, 1.70; loss on ignition - 12.92, 5.09; total nitrogen (N) 0.45, 0.18; silica ($SiO_2$) -

62.24, 62.49; total phosphorus ($P_2O_5$) – 0.20, 0.18; total calcium ($CaO$) – 1.36, 1.30; total magnesium ($MgO$) – 1.38, 2.08; total potassium ($K_2O$) – 3.09, 3.17; total iron ($Fe_2O_3$) – 5.85, 6.28; sesquioxides ($Al_2O_3$, $Mn_3$ $O_4$ $TiO_2$) – 12.99, 15.35. From the above data it may be seen that the soils were extremely high in organic matter, high in total calcium and high in total potash, while percentage of total phosphorus is fairly low.

The plots under study were 1 × 2 rods, and the following symbols will be used to designate the fertilizer treatments:— Ca. = ground limestone at 2 tons per acre to Series I in October 1930, and the same rate to Series II in October 1931; N = 100 lbs. 15% nitrate of soda in April and 100 lbs. Nitro-chalk in June to Series I in 1931 and 1932, while Series II received 100 lbs. 15% Nitro-chalk in April and again in June 1932; P = 500 lbs. 16% superphosphate to Series I in April 1932, and same rate to Series II in April 1932; K = 160 lbs. 48% muriate of potash to Series I in April 1931 and 160 lbs. to Series II in April 1932.

## CLIMATE

Meteorological data were obtained through the Dominion of Canada Meteorological Service from the station located at Farnham (about 15 miles west of the experimental area). The average precipitation for ten years was 38.15 inches, while the mean annual temperature was 42.3°F, and the hours of sunshine were 1757. The rainfall was distributed more favourably during the pasture season in 1932 than in 1931.

## METHODS

The experimental plots were located in permanent pastures that were grazed continually. These plots were not fenced off from the main part of the pasture, and the cows had free access to them. Yields were determined by placing a wire cage, covering one square yard of the area in each small plot. All herbage was harvested by means of grass clippers, and the cuts were made close to the ground level and were therefore drastic. The clippings were made four times during the season, and after every clipping the cages were moved to fresh areas which had been grazed continually thereby approximating grazing conditions as much as possible, and at the same time getting a more randomized sample of the vegetation from each plot. The cages were always placed on areas that were a fair representation of the plot under that particular treatment.

In the late summer and early fall, the botanical composition was determined by estimating the degree in which any particular species covered the ground, as expressed by the collective crown spread of all the individual plants (Hanson and Love, (*14*) ). A quadrat 20 × 20 cms. was used on Series I, and 50 × 50 cms. on Series II, the quadrat area being divided into 25 equal squares by means of fine steel wire. In calculating the cover-degree, account was taken of all plants which were in the quadrat by expressing them first in units of 1 to 10 per small square, and then calculating them in percentage of the total area. Four quadrats were permanently located on each plot and readings were taken about the same date in 1931 and 1932 on Series I so that they were as nearly comparable as possible. There was no attempt made to estimate the botanical composition on the plots before treatment, because the fertilizers were applied in the spring before growth started.

## RESULTS AND DISCUSSION

Since Series I and Series II were started during different years, it is thought best to deal with the results separately before drawing any general conclusions on the effects of fertilizers on the yield and botanical composition of the pastures.

### YIELD—SERIES I

Space does not permit giving the yields per farm per clipping for each treatment, but Table 1 shows the actual and relative yields for 1931 and 1932.

TABLE 1.—TOTAL YIELDS IN GRAMS DRY MATTER PER SQUARE YARD AND THE RELATIVE YIELDS WITH NIL (UNTREATED = 100). SERIES I, SEASONS 1931 AND 1932.

| Treatment | 1931 | | 1932 | |
|---|---|---|---|---|
| | Actual | Relative | Actual | Relative |
| Ca N P K | 2857 | 200.49 | 2195 | 169.76 |
| N P K | 2734 | 191.86 | 1853 | 142.31 |
| Ca P K | 2642 | 185.40 | 1871 | 144.70 |
| P K | 2427 | 170.31 | 1656 | 128.07 |
| Ca | 1611 | 113.05 | 1450 | 112.14 |
| nil | 1425 | 100.00 | 1293 | 100.00 |
| Ca P | 2302 | 161.54 | 1653 | 127.84 |
| P | 1966 | 137.96 | 1557 | 120.42 |
| Ca K | 1767 | 124.00 | 1280 | 98.99 |
| K | 1473 | 103.37 | 1137 | 87.93 |
| Total | 21204 | | 15945 | |

In 1931 the treatment which produced the highest yield was Ca N P K, with N P K the second highest. The plots placed in the order of the total productivity were :—Ca N P K, N P K, Ca P K, P K, Ca P, P, Ca K, Ca, K, and nil. In 1932 the order of productivity is slightly changed. The increases due to fertilizers were not as great and although the treatment giving the best result was again Ca N P K, the order was:—Ca N P K, Ca P K, P K, Ca P, P, Ca, nil, Ca K, and K.

A general statistical treatment of the yields in 1931 is presented in Table 2. The yields in 1932 were subjected to similar statistical treatment but only the results are given. The plots were not replicated on the same farm, but farms are taken as replicates. The treatments were not randomized, but the statistical methods followed were those described by Fisher and Wishart (*10*). In summarized form the results obtained by 'Z' test are as follows:

(1) Ca (involving all plots) gave significant increases in the total yield in 1931 and 1932. In 1931 the 'Z' value is above the 1% point, while in 1932 it falls between *5* and 1%.

TABLE 2.—STATISTICAL TREATMENT OF THE YIELD. DRY WEIGHT IN GRAMS PER SQUARE YARD. SERIES I, 1931.

| | Analysis of Variance | | | | | | |
|---|---|---|---|---|---|---|---|
| | Sum of squares | D.F. | Mean square | ½ log e (M.S.) | Z Value | Z values for | |
| | | | | | | 5% | 1% |
| Treatments | 109544.18 | 9 | 12171.57 | 4.7032 | 1.5004 | .3791 | .5490 |
| Farms | 209211.70 | 5 | 41842.34 | 5.3208 | 2.1180 | .4480 | .6294 |
| Error (1) | 27237.73 | 45 | 605.28 | 3.2028 | | | |
| Cuttings | 113393.50 | 3 | 37797.83 | 5.2699 | 2.4905 | .6729 | .9462 |
| Interaction (treat. on cut.) | 13589.58 | 27 | 503.32 | 3.1106 | .3312 | .1906 | .2664 |
| " (cut. on farms.) | 48791.60 | 15 | 3252.77 | 4.0435 | 1.2641 | .2625 | .3660 |
| Error (2) | 35042.31 | 135 | 259.57 | 2.7794 | | | |
| Treatments may be divided as follows: | | | | | | | |
| (1) Ca *vs.* no Ca (240 plots) | 5548.82 | 1 | 5548.82 | 4 3106 | 1.1078 | .7037 | .9950 |
| (2) Nitrogen treatments (48 plots) | | | | | | | |
| (a) N *vs.* no N | 2838 38 | 1 | 2838.38 | 3.9754 | 7726 | .7037 | .9950 |
| (b) Ca *vs.* Ca in this test | 1190.04 | 1 | 1190.04 | 3 5409 | .3381 | .7037 | .9950 |
| (c) Interaction N and Ca | 176.33 | 1 | 176.33 | 2.5861 | | | |
| (3) Mineral treatments (192 plots) | | | | | | | |
| (a) P *vs.* no P | 48800.63 | 1 | 48800.63 | 5.3977 | 2.1949 | .7037 | .9950 |
| (b) K *vs.* no K | 5260.55 | 1 | 5260 55 | 4.2839 | 1.0811 | .7037 | .9950 |
| (c) Ca *vs.* no Ca (less N plots) | 5536.26 | 1 | 5536.26 | 4 3095 | 1.1067 | .7037 | .9950 |
| (d) Interaction P and K | 1856 30 | 1 | 1856.30 | 3.7632 | .5604 | .7037 | .9950 |
| (e) " P and Ca | 26.25 | 1 | 26.25 | 1.6338 | | | |
| (f) " K and Ca | 0.88 | 1 | 0.88 | $\bar{1}.9303$ | | | |
| (g) " PK & Ca | 273.13 | 1 | 273.13 | 2.8049 | | | |

(2) Nitrogen and corresponding no nitrogen plots:—

(a) N gave significant increases in yield in 1931 and in 1932, the 'Z' value falling between 5 and 1%.

(b) Ca in this test gave no significant increases in 1931, but in 1932 the 'Z' value was between the 5 and the 1% point.

(c) There were no significant differences in the yield due to the interaction of N and Ca in 1931 and 1932.

(3) Other treatments less nitrogen plots:

(a) P is by far the most important element in increasing the yield of vegetation in 1931 and 1932. This element is superior to all others.

(b) K gave a significant increase in yield in 1931 but not in 1932.

(c) Ca (less N plots) gave significant increases in yield in 1931, but not in 1932.

(d) Interaction or combination of P and K gave no significant differences over the sum of differences of these two added separately.

(e) Interaction of P and Ca was not significant.

(f) Interaction of K and Ca was not significant.

(g) Interaction of P K and Ca was not significant.

However, when the standard error test is applied it will be seen that the plots which are significant above the nil (untreated) plots are: Ca N P K, N P K, Ca P K, P K and Ca in 1931 and only Ca N P K in 1932. All other treatments show no significant differences above the unfertilized plots.

Table 3 shows the standard error test for the yields of Series I in 1931. The necessary differences for significance have been calculated so that any group of plots may be examined immediately.

TABLE 3.—STANDARD ERROR TEST OF YIELD. SERIES I, 1931.

| | |
|---|---|
| Variance of single plot | 605.28 |
| Variance of total of 6 plots | 3,631.68 |
| Standard error of total of 6 plots | 60.26 |
| Standard error of one | 10.04 |
| Standard error of difference between 2 means | 14.20 |

*Mean yields per treatment*

| Ca N P K. | N P K. | Ca P K. | P K. | Ca. | Nil. | Ca P. | P. | Ca K. | K. | Mean |
|---|---|---|---|---|---|---|---|---|---|---|
| 119.04 | 113.92 | 110.08 | 101.12 | 67.12 | 59.37 | 95.92 | 81.92 | 73.62 | 61.37 | 88.35 |

*Necessary differences for significance.*

| Number of plots in group | P = .05 | P = .01 |
|---|---|---|
| 1 *vs.* 1 | 27.83 | 36.58 |
| 2 *vs.* 2 | 19.68 | 25.88 |
| 3 *vs.* 3 | 16 07 | 21.12 |
| 4 *vs.* 4 | 13 91 | 18.29 |
| 5 *vs.* 5 | 12.45 | 16.36 |

*Actual increase or decrease over nil treatment*

| | | |
|---|---|---|
| Ca N P K | + 59.67 | significant |
| N P K | + 54.55 | significant |
| Ca P K | + 50.71 | significant |
| P K | + 41.75 | significant |
| Ca | + 7.75 | not significant |
| Ca P | + 36.55 | significant |
| P | + 22.55 | not significant |
| Ca K | + 14.25 | not significant |
| K | + 2 00 | not significant |

## Yield—Series II

Table 4 shows the actual and relative yields of Series II. From this table it is seen that the effect of fertilizers is almost similar to that of Series I in 1931, but that Ca had the opposite effect. The treatment that produced the highest yield was N P K. The treatments in the order of production are: N P K, P K, Ca N P K, Ca P K, P, Ca P, Ca K, K, nil and Ca. From the statistical analyses by variance method, the following results were obtained.

(1) Ca (all plots involved) gave significant differences. From the original data, it is clear that Ca had a depressing effect on yield, so that under the conditions of this experiment Ca had a significant depressing effect.

(2) Nitrogen and corresponding no nitrogen plots:—

  (a) N gave significant increase in yield, the values falling between 5 and 1%.

  (b) Ca in this test, gave significant depressing effect.

  (c) There were no significant differences in yield due to the interaction of N and Ca.

(3) Other treatments less N plots:—
  (a) P gave significant increases in yield. This element is the most important in increasing the yield.
  (b) K gave significant increases in yield.
  (c) Ca gave no significant differences in plots less N treatments.
  (d) Interaction of P and K gave no significant differences over the sum of the differences of these two added separately.
  (e) Interaction of P and Ca was not significant.
  (f) Interaction of K and Ca was not significant.
  (g) Interaction of P K and Ca was not significant.

TABLE 4.—TOTAL ACTUAL YIELDS IN GRAMS DRY MATTER PER SQUARE YARD AND THE RELATIVE YIELDS WITH NIL (UNTREATED = 100). SERIES II, 1932.

| Treatment | Actual | Relative |
|---|---|---|
| Ca N P K | 1219 | 159.55 |
| N P K | 1558 | 203.93 |
| Ca P K | 1164 | 152 36 |
| P K | 1288 | 168 59 |
| Ca | 740 | 96.86 |
| Nil | 764 | 100.00 |
| Ca P | 953 | 124.74 |
| P | 1124 | 147.12 |
| Ca K | 909 | 118.98 |
| K | 857 | 112.17 |

By the standard error test, the plots that were significantly superior in yield over nil (untreated) plots were :—Ca N P K, N P K, Ca P K, and P K. All other treatments gave no significant increases or decreases.

## DISCUSSION OF YIELD RESULTS

From the statistical treatments of the yields of Series I and Series II, it is clearly seen that there are significant differences due to treatments. When the treatments are analyzed by the 'Z' test or the standard error test, it is seen that Ca had a significant effect in increasing the yields in Series I, but a significant effect in decreasing the yields in Series II. Brenchley (*3*, *4*) obtained results showing that Ca had a depressing effect on the yields on soils high in organic matter or with an application of organic manure. The soils under study are all very similar and such opposite results cannot be explained on the basis of difference in soils. It is very unlikely that such differences are due to chance, because the 'Z' values fall above the 1% point in each case. By the 'Z' test of the yields, we see that all other elements produced similar results in both series. Phosphorus, potash, and nitrogen increased the yield wherever applied. Here it might be well to state that in

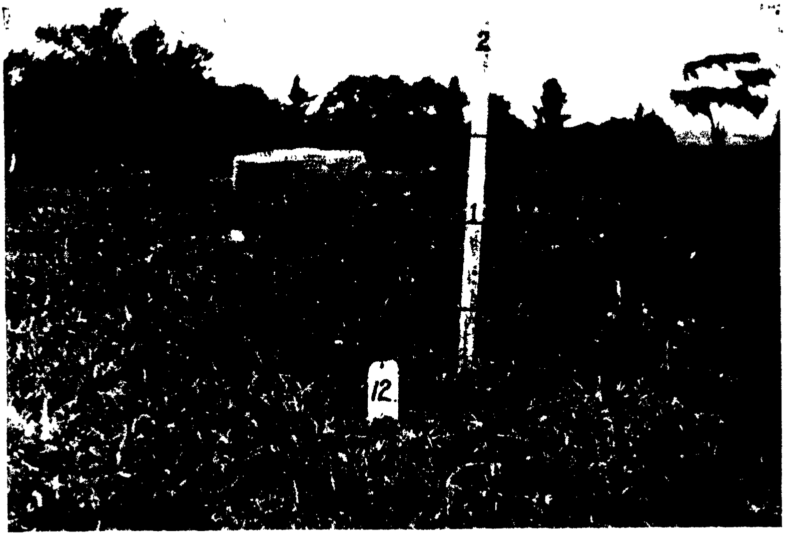

Figure 1. The untreated plot had a high percentage of grasses, but very little clover. (Series 1, F. H Pickle, nil, 1931).

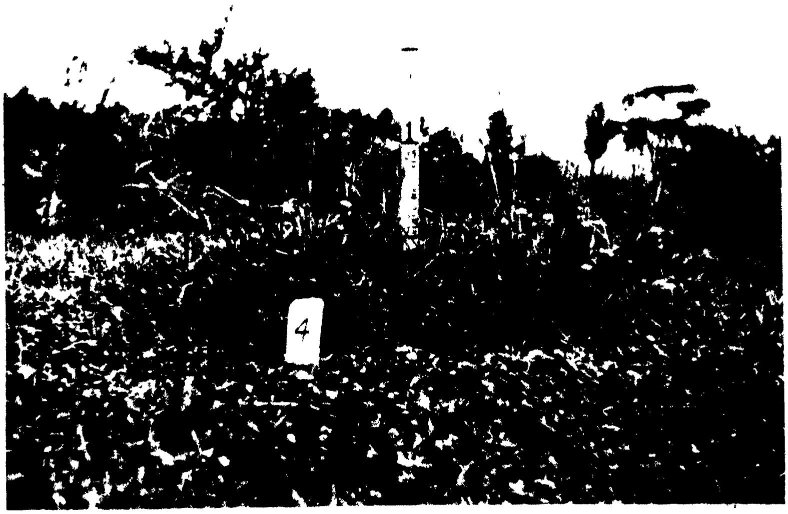

Figure 2. The application of minerals and nitrogen increased the yield and improved the character of the vegetation. (Series 1, F. H. Pickle, N P K, 1931).

Series I, 1932, second year effects were measured on all but nitrogen treatments. From the standard error tests we see that the treatments which gave significant increases over the nil (untreated) plots in the first year of their application were similar, being Ca N P K, N P K, Ca P K, P K, and Ca P, while in Series I, 1932 (second year effect) only Ca N P K gave significant increases.

It is too early to draw any conclusions on the longevity of different treatments, but they seem to indicate that under the conditions of these experiments, the differences in the second year are not as great as in the first year.

### BOTANICAL COMPOSITION, SERIES I

Space does not permit giving tables showing the percentage of ground covered by different species in 1931 and 1932. There were more species listed in 1932 than in 1931. This may be a seasonal variation. The additional species are of minor importance. However, there was a great reduction in clovers and an increase in grasses, chiefly *Agrostis alba*, from 1931 to 1932. This was a general change and occurred in every treatment, and may be partly accounted for by a lower precipitation during growing months. The precipitation for the five growing months in 1931 was 19.90 inches and only 14.71 inches in 1932. Table 5 gives the percentage of ground covered by different groups of species. In 1931 the plots having the highest percentage of clovers were P K with 46.89%. At the same time all nil (untreated) plots had 17.19% clover. The highest percentage of useful grasses in that year was on Ca plots with 41.38% and the lowest on P K with 26.95%. The same order holds true in 1932. The highest percentage covered by weeds in 1931 was on P plots and the lowest on Ca N P K. In 1932 the highest was on nil (untreated) plots and the lowest on Ca P K. Moss occupied the highest percentage of ground on Ca plots in 1931 and in 1932. The lowest in both years was on P K plots. The percentage of bare ground was highest in both years on the unfertilized plots.

The data showing the percentage of ground covered by clovers, grasses, weeds, miscellaneous plants, moss and bare ground of Series I were analyzed by the variance method and for brevity the results are summarized in chart form in Table 6. This chart gives the difference due to different treatments and shows whether these treatments increased or decreased the percentage of ground covered by different groups of species.

The differences due to treatments were significant for clover in 1931 and 1932, weeds in 1932, moss and bare ground in 1931. Treatments had no significant effect on grasses and weeds in 1931, miscellaneous plants in both years, and moss and bare ground in 1932. When different treatments were examined statistically it is clearly seen that Ca had no significant effect on clovers. It had a significant effect in increasing grasses in 1931 and 1932, decreasing weeds in 1931 and 1932, and decreasing moss and bare ground in 1931. P was significant in increasing clovers in 1931 and 1932, and in decreasing the bare ground in 1931. K could not be studied statistically, because the plots receiving K and Ca K were not estimated for botanical composition.

TABLE 5.—AVERAGE PERCENTAGE OF GROUND COVERED BY CLOVERS, USEFUL GRASSES, WEEDS, MISCELLANEOUS PLANTS AND MOSS AS WELL AS THE PERCENTAGE BARE GROUND. AVERAGE OF SIX AREAS. SERIES I, SEPTEMBER, 1931 AND 1932

| Vegetation | Ca N P K | | N P K | | Ca P K | | P K | | Ca | | Nil | | Ca P | | P | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1931 | 1932 | 1931 | 1932 | 1931 | 1932 | 1931 | 1932 | 1931 | 1932 | 1931 | 1932 | 1931 | 1932 | 1931 | 1932 |
| Clovers | 45.52 | 33.79 | 43.56 | 29.34 | 45.87 | 28 23 | 46.89 | 36.14 | 19.35 | 16.46 | 17.19 | 13.49 | 37.41 | 27.66 | 29.31 | 21.89 |
| Useful grasses | 35.53 | 45.24 | 30.00 | 47.89 | 32.26 | 48.85 | 26 95 | 38 51 | 41.38 | 53 12 | 31.94 | 42.03 | 32.36 | 46.83 | 28.18 | 42.62 |
| Weeds | 8.59 | 5.08 | 11.94 | 7.25 | 9.21 | 4.78 | 10.11 | 7.93 | 14.62 | 10.38 | 18.11 | 15.80 | 13.05 | 7.26 | 19.26 | 15.12 |
| Miscellaneous | 3.26 | 4.22 | 2.31 | 3 39 | 2.57 | 3.71 | 2.62 | 4.37 | 5.98 | 6.01 | 5.78 | 7 11 | 3.21 | 4.16 | 4.95 | 5.96 |
| Moss | 1.08 | 1.62 | 1.35 | 2.83 | 2 86 | 3.30 | .87 | 1.47 | 7.32 | 4.53 | 4.93 | 3.49 | 2.10 | 2 06 | 1.94 | 2.72 |
| Bare ground | 6.02 | 10.05 | 10.84 | 9.30 | 7.23 | 11.13 | 12.56 | 11.58 | 11.35 | 9.50 | 22.05 | 18.08 | 19.97 | 12.03 | 16.36 | 11.69 |

TABLE 6.—SUMMARY OF THE STATISTICAL TREATMENT OF THE PERCENTAGE COVER-DEGREE OF CLOVERS, GRASSES, WEEDS, MISCELLANEOUS PLANTS, MOSS AND BARE GROUND. SERIES I. SEPTEMBER, 1931 AND 1932.

| Due to | Analysis of Variance* | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Clovers significant to | | | | Grasses significant to | | | | Weeds significant to | | | | Miscellaneous significant to | | | | Moss and bare ground significant to | | | |
| | 5% | | 1% | | 5% | | 1% | | 5% | | 1% | | 5% | | 1% | | 5% | | 1% | |
| | '31 | '32 | '31 | '32 | '31 | '32 | '31 | '32 | '31 | '32 | '31 | '32 | '31 | '32 | '31 | '32 | '31 | '32 | '31 | '32 |
| Treatments | | | X | X | O | O | | | O | | | X | O | O | | | | O | X | |
| Farms | | | X | X | | | X | X | | | X | X | | | X | X | | | X | X |
| Treatments may be divided as follows: | | | | | | | | | | | | | | | | | | | | |
| Ca *vs.* no Ca | O | O | | | + | + | | | — | | | — | O | O | | | | O | — | |
| P *vs.* no P | | | + | + | O | O | | | O | O | | | O | O | | | — | O | | |
| Interaction P and Ca | O | O | | | O | O | | | O | O | | | O | O | | | O | O | | |
| " P K and Ca | O | — | | | O | O | | | O | O | | | O | O | | | O | O | | |
| Nitrogen treatments | | | | | | | | | | | | | | | | | | | | |
| N *vs.* no N | O | O | | | O | O | | | O | O | | | + | O | | | O | O | | |
| Ca *vs.* no Ca | O | O | | | O | O | | | O | O | | | | O | + | | O | O | | |
| Interaction Ca and N | O | + | | | O | O | | | O | O | | | O | O | | | O | O | | |

* Legend: X = significant difference. O = no significant differences. + = significant increases. — = significant decreases.

## BOTANICAL COMPOSITION, SERIES II

In general, it may be stated that there was more bare ground present in this series than in Series I. Any differences between different treatments were not very great, because the fertilizers were applied in April and the readings were taken in July, so that the fertilizers had little time to show any great effects. It was found that wherever Ca was added to any treatment, the percentage of clover decreased. When these data were examined statistically it was found that Ca had a significant effect in decreasing the percentage of ground covered by clovers. At the same time, grasses and weeds were increased, while miscellaneous plants decreased. P and K increased the percentage of clovers and decreased weeds, miscellaneous plants, moss and bare ground. N had a significant effect in decreasing the clovers, but did not increase the percentage of grasses to any significant extent. N increased the percentage of weeds.

## DISCUSSION OF BOTANICAL COMPOSITION

From the statistical analysis of the percentage of ground covered by groups of species in Series I and Series II, it is seen that Ca had an increasing effect on clovers in Series I and a decreasing effect in Series II. This seems to agree very closely with the analysis of the yields. It is clear that P increased the percentage of clovers in all plots and in most cases weeds and bare ground were reduced. K had very similar effects wherever it was possible to measure these differences statistically.

The addition of P to Ca increased the growth of all plants and increased the percentage of clovers.

Nitrogen was another element which produced a significant decrease in the percentage of clover in Series II. However, N in Series I did not show any significant difference.

It is very difficult to explain some of the results presented, because vegetation is of a very complex nature. A stimulation in growth of one species, immediately causes greater competition in the sward, and may suppress other lesser species. For instance, in Series II where Ca increased the grasses, we immediately see a significant decrease in clovers. For these reasons we have to draw conclusions with caution, especially when all data do not show similar results.

## SUMMARY AND CONCLUSIONS

The results of the pasture experiments conducted in the Eastern Townships at Cowansville, Que., are summarized as follows:—

A. Yield of herbage.

(1) In the first experiment (Series I) studied in 1931 and 1932, on brown forest soil, lime (Ca) produced significant increases in yield.

(2) In the second experiment (Series II) on a similar type of soil and studied in 1932, lime (Ca) produced significant decreases in yield.

(3) The plots in the order of highest productivity in the first experiment in 1931 (first year effect), were:—Ca N P K, N P K, Ca P K, P K, Ca P, P, Ca K, Ca, K, and nil. Of these plots the ones which were significantly better than the untreated plots were: Ca N P K, N P K, Ca P K, P K, and Ca P.

(4) The plots in the order of highest productivity in the first experiment in 1932 (second year effect except addition of N) were: Ca N P K, Ca P K, N P K, P K, Ca P, P, nil, and Ca K. Of these plots only Ca N P K was significantly superior to the untreated plots.

(5) In the second experiment in 1932, the plots in the order of productivity (first year effect) were: N P K, P K, Ca N P K, Ca P K, P, Ca P, Ca K, K, nil, and Ca. Of these, the plots significantly superior to the untreated plots were: N P K, P K, Ca N P K, and Ca P K.

B. Botanical Composition.

(1) The botanical composition was determined on the plots each year of the experiment. The results are not very definite as yet, but it is seen that treatments have an effect on the proportion of species.

(2) In the first experiment, lime (Ca) increased the percentage of useful grasses, and decreased the weeds, moss and bare ground. Superphosphate (P) increased the clovers in both years (i.e. first and second year effects). All other elements failed to produce any significant results.

(3) In the second experiment, lime (Ca) increased the percentage of grass, but also decreased the percentage of clovers. Superphosphate (P) and potash (K) increased the clovers in this experiment. Nitrogen (N) was effective in decreasing clovers, but also increased the percentage of weeds.

(4) The botanical analysis brought out the importance of such work in the interpretation of the yields obtained from plots under different treatments, but as yet no definite conclusions can be drawn.

## ACKNOWLEDGEMENT

Acknowledgement is due to Mr. L. C. Raymond, Assistant Professor of Agronomy, Macdonald College, who has given invaluable advice and criticism in connection with the accumulation and interpretation of the results presented in this thesis, and to Professor R. Summerby, Agronomy Department, Macdonald College, for the assistance in the statistical treatment of the data. Acknowledgement is also due to Dr. R. R. McKibbin, Assistant Professor of Chemistry, Macdonald College, for the supervision and advice in the chemical analyses reported in this paper.

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# SEED TREATMENT FOR POTATO BLACKLEG[1]

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[Received for publication March 11, 1933]

Seed potato treatment, with bichloride of mercury or with formalin, to control certain diseases is a practice that has been followed by many growers for some years. With the low prices now in effect, growers are naturally more anxious to know whether the practice is economically sound. They are not particularly interested in ascertaining how the chemicals used destroy diseases; they prefer rather to know whether they can reasonably expect additional returns from the crop, in quality or quantity, sufficient to repay the cost of materials used.

The following summaries have been assembled to show the effect of seed treatment on potato blackleg. Apart from blackleg, chemical treatment may be of value in destroying the organisms on rhizoctonia and scab infested potatoes should it become necessary to use seed of such poor quality, but when seed that is free of these diseases is treated the object presumably is to control blackleg. The value of these summaries, especially from the grower's point of view, lies in the fact that they record results that have been obtained by seed treatment under practical conditions, and in representative potato growing areas in every province of the Dominion.

The field inspection work in connection with the seed potato certification service presented an excellent opportunity of collecting the necessary information. For five successive years the inspectors were required to state on the field reports (1) percentage of plants affected with blackleg, (2) whether seed had been treated, and (3) if so, what chemical used. Two field inspections were made each season and the reports compared and checked, incomplete or doubtful reports being rejected.

For the five year period 1928-1932 inclusive, a total of 48,398 fields were reported upon, representing a total of 173,083 acres of potatoes. Reports on 4,374 fields were discarded as lacking complete and satisfactory details on seed treatments, leaving good reports on 44,024 fields which alone are taken into account. Table 1 shows the results of seed treatment with bichloride of mercury and with formalin, as compared with no treatment. The districts referred to are inspectional districts for seed certification work and in most cases refer to provinces.

In these combined records for the five year period it is apparent that the seed for 23,959 fields was not treated and the average loss of crop from blackleg was .34%; that 13,218 growers treated with bichloride and the average loss of crop was .18% ,and that 6,847 growers treated with formalin with an average loss of crop amounting to .31%. In estimating the value of seed treatments, however, a more equitable conclusion would be reached by considering the districts separately. There was not only a wide variation in the number of reports per district, but the two treatments were not equally tested in any one district. Inasmuch as soil types, which have significant bearing on blackleg infection, vary considerably in the different districts,

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TABLE 1.—SEED TREATMENT AND BLACKLEG INFECTION. FIVE YEAR PERIOD, 1928-1932.

| District | No Treatment | | | Bichloride of mercury | | | Formalin | | |
|---|---|---|---|---|---|---|---|---|---|
| | Number of fields inspected | Number of fields infected | Average per cent infection | Number of fields inspected | Number of fields infected | Average per cent infection | Number of fields inspected | Number of fields infected | Average per cent infection |
| No. 1 | 12916 | 3835 | .85% | 11104 | 2480 | .74% | 282 | 97 | 1.01% |
| No. 2 | 866 | 128 | .73% | 19 | 4 | 1.0% | 985 | 146 | .58% |
| No. 3 | 3786 | 1838 | .47% | 40 | 14 | .27% | 198 | 104 | .48% |
| No. 4 | 3459 | 1691 | 1.39% | 26 | 8 | 1.29% | 3883 | 1212 | 1.11% |
| No. 5 | 1262 | 835 | 1.13% | 1162 | 600 | .68% | 452 | 281 | 1.07% |
| No. 6 | 446 | 212 | 1.38% | 32 | 10 | 1.07% | 27 | 4 | .5% |
| No. 7 | 389 | 94 | 1.69% | 52 | 8 | 1.16% | 277 | 59 | 1.86% |
| No. 8 | 269 | 62 | 1.55% | 43 | 6 | 2.71% | 535 | 98 | 1.41% |
| No. 9 | 566 | 138 | 1.53% | 740 | 125 | .80% | 208 | 30 | .89% |
| | 23959 | 8833 | .94% | 13218 | 3255 | .74% | 6847 | 2031 | 1.05% |

any conclusions reached from the summary for the Dominion as a whole would be most misleading.

Bichloride of mercury was given a relevant trial in districts 1, 5 and 9, and formalin in districts 2, 4, 7 and 9. For these districts individually, the following results were obtained:

*Bichloride of mercury treatment:*

District 1.—12,916 growers did not treat: average loss: .25%
11,104 growers treated: average loss: .16%
District 5.— 1,262 growers did not treat: average loss: .75%
1,162 growers treated: average loss: .35%
District 9.— 566 growers did not treat: average loss: .37%
740 growers treated: average loss: .13%

TOTAL OF 3 DISTRICTS

14,744 growers did not treat: average loss: .30%
13,006 growers treated: average loss: .18%

*Formalin treatment:*

District 2.— 866 growers did not treat: average loss: .11%
985 growers treated: average loss: .08%
District 4.— 3,459 growers did not treat: average loss: .68%
3,883 growers treated: average loss: .35%
District 7.— 389 growers did not treat: average loss: .41%
277 growers treated: average loss: .39%
District 8.— 269 growers did not treat: average loss: .36%
535 growers treated: average loss: .26%

TOTAL OF 4 DISTRICTS

4,983 growers did not treat: average loss: .54%
5,680 growers treated: average loss: .29%

The records over a period of five years show, therefore, that neither bichloride of mercury nor formalin controls blackleg, but that each treatment reduces the losses due to this disease.

In checking over the reports it was apparent that local conditions have considerable effect on the extent of the disease. In certain well favoured locations where the disease does not reach serious proportions, the growers do not generally treat their seed, and still secure crops showing little or no disease. In other locations, where conditions are more favourable to the development of blackleg, growers more generally treat their seed. This procedure most probably results in a reduction of the percentage of infection which it is not possible to indicate here. These conditions should receive consideration when comparing the non-treated with the treated classes.

The seed used in all cases originated from fields which passed inspection the previous season. Taken as a whole it would appear that the results obtained do not warrant the cost of treatment if certified seed is used, but the fact that practically the only fields that showed a relatively large amount of blackleg were planted with untreated seed, appears to indicate that there are individual cases where it might be profitable to practice seed treatment.

## CURRENT PUALICATIONS

### THE EFFECT OF AGEING AND HEAT ON THE CHROMOSOMAL MUTATION RATES IN MAIZE AND BARLEY. F. H. Peto, National Research Laboratories, Ottawa. Canadian Journal of Research, *9:* 261-264. 1933.

The recent discovery by Navashin (3), that the chromosomal mutation rate in *Crepis* was influenced by aging of the seed, has been corroborated by obesrvations on the mutation rate of corn plants from seed of various ages. A very high chromosomal mutation rate in barley was induced by heat treatments of seed under various conditions of humidity. The most common type of aberration resulting from these treatments appeared to be fracture of the chromosomes either at the attachment constriction, the secondary constriction or the point of attachment of the trabants. The reattachment of fragments to other chromosomes was observed in two instances. Considerable importance is attached to the discovery that a large proportion of the mutant cells are eliminated during the growth of the plant. The principle that only the *fittest survive* seems equally true of cells as of individuals and groups of plants or animals.

# THE ECONOMIC ANNALIST

A REVIEW OF AGRICULTURAL BUSINESS PREPARED QUARTERLY BY
THE AGRICULTURAL ECONOMICS BRANCH
DEPARTMENT OF AGRICULTURE
OTTAWA

Vol. III. Nos. 7, 8, 9. July, Aug., Sept., 1933.

## THE ECONOMIC SITUATION

The index number of wholesale prices in Canada, computed by the Dominion Bureau of Statistics, rose to 67.6 in June and reached 70.5 in July. In August, however, prices barely held and the index receded to 69.4. The chief factor in the price decline is to be found in the vegetable products group in which the index fell from 69.8 to 65.7. There was also a slight reaction in non-ferrous metals and their products.

*Retail Prices.*—Retail prices reached the low point of 77.0 in May and held even during June. The July index was up fractionally whereas that for August rose rather sharply to 78.6. Prices of food and fuel were largely responsible. The food index rose from 63.2 in July to 67.8 in August and was the chief cause of the higher index. The sundries group published by the Bureau of Statistics has been revised and thus revision of the total index of retail prices has been necessary.

*Employment.*—The employment index rose from 87.5 in July to 88.5 in August. After seasonal correction the respective figures were 83.0 and 84.8. The Bureau of Statistics reports that those firms regularly making returns showed an increase in employment of 116,000 persons during the five months from April 1 to August 31.

*Physical Volume of Business.*—Physical volume of business continued to increase in August. The index advanced from 84.1 in July to 89.8 in August. Similarly, the index of industrial products advanced from 84.1 to 89.5. Substantial gains were made in mineral production in which group the index was 78.3 in July and 95.7 in August. Manufacturing also showed considerable improvement, the index rising from 88.2 to 96.9. Construction, however, was lower, the index declining from 34.0 to 25.5. Electrical power production was higher.

*Agricultural Products.*—The index number of wholesale prices of Canadian farm products was 60.1 in July but declined to 57.0 in August. The chief cause of the lowered index is to be found in the decline in prices of grain, particularly wheat, although grains did improve their position somewhat toward the end of August. Prices of domestic fresh fruit and vegetables were also lower.

The index of animal products, on the other hand, advanced from 59.0 to 60.5. Better prices for hogs and calves were largely responsible for this increase because cattle and lamb prices were lower.

The index of agricultural marketings rose from 136.3 to 197.2. The movement of grain which is often not large in August was above normal and the index of grain marketings moved up to 224.6. Live stock marketings on the other hand, were lower, falling from 81.2 to 74.5. The movement of cattle was lighter and lamb marketings were somewhat less than normal whereas shipments of calves were higher. Hogs were marketed in about the same volume as in July.

The indexes of cold storage holdings indicate very little change in July and August.

## ANNUAL AND MONTHLY INDEX NUMBERS OF PRICES AND PRODUCTION COMPUTED BY DOMINION BUREAU OF STATISTICS

| Year | Wholesale Prices 1926=100 | | | | Retail prices and cost of services (5) | Production (6) 1926=100 | | | |
|---|---|---|---|---|---|---|---|---|---|
| | All commodities (1) | Farm products (2) | Field products (3) | Animal products (4) | | Physical volume of business | Industrial production | Agricultural marketings | Cold Storage holdings |
| 1913.... | 64.0 | 62.6 | 56.4 | 77.0 | 65.4 | .... | .... | .... | .... |
| 1914.... | 65.5 | 69.2 | 64.9 | 79.0 | 66.0 | .... | .... | .... | .... |
| 1915.... | 70 4 | 77.7 | 76.9 | 79.2 | 67 3 | .... | .... | .... | .... |
| 1916.... | 84.3 | 89.7 | 88.4 | 92.3 | 72.5 | .... | .... | .... | .... |
| 1917 ... | 114.3 | 130.0 | 134.3 | 119.6 | 85.6 | .... | .... | .... | .... |
| 1918.... | 127.4 | 132.9 | 132.0 | 134.7 | 97.4 | .... | .... | .... | .... |
| 1919.... | 134.0 | 145.5 | 142.4 | 152.5 | 107 2 | 71.3 | 65.5 | 48.1 | 47.1 |
| 1920.... | 155.9 | 161.6 | 166.5 | 149.9 | 124.2 | 75.0 | 69.9 | 52.6 | 94.2 |
| 1921.... | 110 0 | 102.8 | 100.3 | 108.5 | 109.2 | 66 5 | 60.4 | 65.2 | 86.4 |
| 1922.... | 97.3 | 86.7 | 81 3 | 99.1 | 100.0 | 79 1 | 76.9 | 82.6 | 82.6 |
| 1923.... | 98 0 | 79.8 | 73.3 | 95.1 | 100.0 | 85.5 | 83.8 | 91.4 | 87.8 |
| 1924.... | 99.4 | 87.0 | 82.6 | 97.2 | 98 0 | 84.6 | 82.4 | 102.5 | 114.6 |
| 1925.... | 102.6 | 100.4 | 98.1 | 105.7 | 99 3 | 90 9 | 89 7 | 97 2 | 108.9 |
| 1926.... | 100.0 | 100.0 | 100.0 | 100.0 | 100 0 | 100.0 | 100 0 | 100.0 | 100.0 |
| 1927.... | 97 7 | 102 1 | 99 9 | 105.7 | 98 4 | 106 1 | 105 6 | 103.6 | 110.0 |
| 1928.... | 96.4 | 100.7 | 92 6 | 114 3 | 98 9 | 117.3 | 117 8 | 146.7 | 112.8 |
| 1929.... | 95.6 | 100.8 | 93.8 | 112.5 | 99.9 | 125.5 | 127.4 | 101.1 | 109.6 |
| 1930.... | 86 6 | 82.3 | 70.0 | 102.9 | 99.2 | 109.5 | 108 0 | 103 0 | 128.4 |
| 1931.... | 72.2 | 56.3 | 43 6 | 77 6 | 89 6 | 93.5 | 90.4 | 99.0 | 125.7 |
| 1932.... | 66.7 | 48 4 | 41.1 | 60 7 | 81.4 | 78.7 | 74 0 | 114.3 | 120.1 |
| 1933 | | | | | | | | | |
| Jan..... | 63.9 | 43.6 | 35.1 | 57.9 | 79 1 | 68.1 | 62.2 | 56.1 | 112.0 |
| Feb..... | 63.6 | 43.0 | 36.0 | 54.7 | 78.4 | 67.0 | 60.9 | 76 5 | 127.6 |
| Mar.... | 64.4 | 44.7 | 38.0 | 56 0 | 77.8 | 68.4 | 62.5 | 129.0 | 135.8 |
| April... | 65.4 | 46.8 | 41.1 | 56.4 | 78.1 | 69.8 | 65.1 | 104.1 | 112.7 |
| May.... | 66.9 | 51.2 | 46.9 | 58.4 | 77.0 | 76.4 | 72.7 | 95.4 | 100.4 |
| June. .. | 67.6 | 52.6 | 49.4 | 57.9 | 77.0 | 82.2 | 79.8 | 221.9 | 119.9 |
| July.... | 70.5 | 60.1 | 60.8 | 59.0 | 77.2 | 84.1 | 82.6 | 136.3 | 114.5 |
| Aug..... | 69.4 | 57 0 | 54.9 | 60.5 | 78.6 | 89.8 | 89.5 | 197.2 | 114.2 |

1. See Prices and Price Indexes 1913-1928, pp. 19-21, 270-289 and 1913-1931, p. 15.

2. Wholesale prices of Canadian products of farm origin only. See Prices and Price Indexes 1913-1931, p. 33, and Monthly Mimeographs 1932 and 1933.

3. Wholesale prices of grains, fruits and vegetables.

4. Wholesale prices of Animals and Animal Products.

5. Including foods, rents, fuel, clothing and sundries, See Prices and Price Indexes 1913-1928, pp. 181-185, 290-293. 1926=100.

Prices and Price Indexes 1913-1931, pp. 122, and Monthly Mimeographs 1932-1933.

6. Monthly Review of Business Statistics, pp. 8, and Monthly Indexes of the Physical volume of business in Canada, supplement to the Monthly Review of Business Statistics, November, 1932.

The apple crop in Canada is estimated by the Fruit Branch to be 16% above last year. In Nova Scotia production is placed at 1,846,000 barrels or 75% above 1932. In New Brunswick the crop is just equal to that of a year ago, 40,000 barrels. In Quebec, latest reports indicate that the crop will be within 2% of last year's crop or 254,000 barrels. The crop in Ontario is 15% above that of a year ago and is placed at 1,064,000. British Columbia has a smaller crop this year, estimated at 4,182,000 boxes, or 18% lower than in 1932.

Butter production during the seven months ended July 1933, showed an increase of 2.1% over that for the same period in 1932. The increase in Alberta is estimated at 11.1%, in Saskatchewan 7.9%, Ontario 5.3%, British Columbia 4.8%, Nova Scotia 3.1% and Prince Edward Island 3.2%. There was a very slight decline in New Brunswick while production declined 3.5% in Quebec and 1.6% in Manitoba.

Cheese production has been at a somewhat lower level thus far in 1933. The number of boxes graded during the period from November 28, 1932 to September 2, 1933 was 763,659 as compared with 875,567 during approximately the same dates in 1931-32. In 1933, however, 93.87% of the boxes graded first whereas 92.89% graded first in 1932.

Sales of cattle at public yards in Canada up to the end of September this year were 750,288 head as compared with 907,890 in 1932. Sales of sheep during the same period were 298,347 as compared with 266,059 last year. Sales of calves were 237,345 in the first nine months of 1932 whereas during that period in 1933 sales amounted to 240,487 head.

Hog gradings during the same period in 1933 were 2,289,668 as against 2,313,841 in 1932. The hog gradings include direct shipments to packing plants.

## PUBLICATION RESUMED

Following curtailment of funds available to this Branch and other Branches of the Government Service it was found to be necessary to cease publication of *The Economic Annalist* which had been issued monthly for two and a half years prior to July 1933. A questionnaire was sent to those whose names were on the mailing list requesting an expression of opinion regarding the usefulness of *The Economic Annalist* and whether they desired to continue to receive similar information. The response justified the belief that *The Economic Annalist* was filling a need for economic information.

We are, therefore, undertaking to publish a quarterly edition containing 16 pages in place of the former 12 page monthly issue. The mailing list has been revised on the basis of replies to our questionnaire.

## MARKETING ACTIVITY AMONG SHEEP RANCHERS

During August and September a series of meetings was held in the range sheep areas of Saskatchewan, Alberta and British Columbia. The Dominion Department of Agriculture was represented at these meetings by L. E. Kindt, Economics Branch, and A. A. MacMillan, Live Stock Branch. The findings and suggestions released in a preliminary report by the Economics and Experimental Farms Branches dealing with the sheep ranch survey conducted during the past three years as well as other matters, were discussed with those present.

As a result of this survey and the meetings held, a definite programme for improvement of the range sheep industry has been launched. One of the important phases of the work undertaken has to do with the marketing of lambs. The Live Stock Branch is making arrangements for the shipment of several thousand lambs to feeding centres in Ontario and there has been an encouraging expansion of feeding operations in the irrigated sections of the West. Contracts have been prepared to facilitate negotiations between ranchers and feeders and to provide for a programme which should prove mutually beneficial. Officers of the Department are effecting these arrangements and are providing for the movement of stock. Later a similar programme designed to move breeding ewes from ranches to farms on a contract-share-of-products basis will in all probability be fostered.

It is too early to say how these plans will work out for much depends upon the action of ranchers and farmers, but the foundation is being laid for a worth while development.

# EFFORTS TO CONTROL MARKETING BY GOVERNMENT BOARDS OR ORGANIZATIONS ACTING WITH GOVERNMENT SUPPORT[1]

J. Coke[2]

This article is the first of three in which Governmental action with respect to control of marketing, more particularly with respect to the creation of boards will be discussed. Quite obviously, the subject is one about which there may be a wide variation in opinion. Some would have the Government confine its efforts to the enforcement of contracts, maintenance of law and order and the defence of trade routes while others advocate a large measure of control of business, even participation in trade. A careful study of what has been attempted would probably lead to modification of these extreme views.

Governmental intervention in marketing is by no means new. For a short time during the nineteenth century the tendency toward regulation and supervision was slackened. It quickened again, however, during the closing years of the century. For example, there was a distinct movement against monopoly. Early in this century the establishment in Canada of the Dominion Board of Railway Commissioners, the Dominion Board of Grain Commissioners and the Combines Investigation Act, increasing Governmental control over grades and standards of farm products and the supervision of marketing facilities all indicate an extension of the power of Government in business enterprise. Again, the necessity of war time control resulted in further extension of Governmental activity, not only in this country but also in many others. Price regulation during war time had two purposes which were opposed to each other. One was used in stimulating supply and in the earlier stages at least, was not so much concerned with costs and profits. In the case of cost of living control including rationing there was a definite scrutiny of costs and profits, the dominant note of such control being not only to conserve supply but also to eliminate "profiteering". It will be recalled that efforts to regulate the marketing of wheat when the matter was first broached in Canada were opposed by many farmers; later on they made an appeal for the reestablishment of a somewhat similar policy. Thus, it may be claimed that war time policy has exerted an influence on marketing policy during the post-war years, and this was foreseen by some economists; for example, in 1918 Prof. Pigou wrote, "The vast expansion of Governmental control in the economic sphere which has taken place during the war is without parallel in the history of the world. Nobody doubts that in the difficult period of transition that must follow immediately upon the declaration of peace some portion at all events of the control must be retained. But on the question of how far similar control is appropriate as a permanent peace policy there is an acute controversy."[3]

However war time policy may have affected post war policy, it is clear that when groups of individuals find themselves faced with falling prices and unable to stem the downward course of prices they eventually turn to their Government and expect it to do something.

In attempting to isolate policies of marketing control I have found a distinct classification to be difficult, for if it be inclusive it necessarily results in duplication because emphasis on the means of control has shifted or else several methods may be provided under a single scheme. However, I think that it will be agreed that most of such policies are concerned with supply, although some efforts to increase demand have been noted. Moreover, in many cases, such policies as I have studied indicate that the concern was exhibited in regard to the distribution of a surplus. This is particularly true of those schemes which relate to price control. A brief outline of certain types of control exercised by or with the consent of Government will, therefore, be presented.

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[1] Largely based on a paper read before the Fifth Annual Meeting of The Canadian Political Science Association held at Ottawa, May 22 and 23, 1933. The original was published in the Proceedings of the Association.

[2] Assistant Commissioner, Agricultural Economics Branch, Department of Agriculture, Ottawa.

[3] Pigou, A. C. Government control in war and peace, Economic Journal, Vol. XXVIII, p. 363.

*Brazilian Coffee Valorization.*—The valorization of coffee is of interest not only because of the experiment itself but also because of the fact that it ultimately resulted in what was believed to be a permanent policy. Valorization implies an increase in price,[4] but it should be noted that the circumstances under which this plan was inaugurated require some explanation. There is normally a wide variation in the yield of coffee per tree. The output is very greatly influenced by weather conditions. A favourable season produces a very large crop which reduces the strength of the tree and a short crop results in the following year. These factors are so closely related that a large crop cannot result unless trees are in good condition and weather favourable. Valorization was, therefore, not so much for the purpose of controlling prices as a scheme to overcome the effects of large and small crops, which may be more essential in the case of coffee than in that of some other commodities because of the fact that consumption of coffee does not change greatly with fluctuations in price. "Broadly speaking, actual physical consumption varies to a quite insignificant extent with the price of green coffee, not only because coffee is a staple drink in all those countries where it is used but also because the price of green coffee forms less than one-third of the cost of coffee to the final consumer and the other two-thirds, representing distribution and processing costs, are virtually fixed and unchanging so far as the short period is concerned."[5]

As early as 1902 a high tax was placed on new plantings to discourage expansion. The first valorization took place in 1905, the second in 1918 and the third in 1921.

The plan was inaugurated as a result of the accumulation of large coffee stocks amounting to almost one year's production. A loan was obtained by the State of Sao Paulo on condition that steps be taken to restrict output and exports. Accordingly, it was enacted that there should be a surtax of about 60 cents per bag on coffee exported and the entries of coffee into the port of Santos limited to 50,000 bags (132 pounds per bag) each business day.[6] This checked the flow to market but was inadequate in so far as the improvement of the market was concerned and, moreover, it left plantation owners in the position of being obliged to hold their coffee without proper storage facilities. The Government then decided to buy a part of the crop and hold it so as to prevent the surplus being thrown on the market. In August, 1908, a law was passed increasing the surtax from three to five francs, about three-quarters of a cent per pound, in addition to the regular export duty of 9%. The law also imposed a 20% surtax on exports over nine million bags during the crop year 1908-09. By this time bankers had begun to have some confidence in the scheme and the necessary credit was forthcoming for its continuance. It is interesting to note that in 1909 the Sao Paulo Government suggested that a tax of 10% payable in kind should be levied and that this coffee should be dumped into the ocean. This suggestion, though approved by bankers, was not carried out, possibly because prices strengthened. In 1914, a surplus of three million bags of coffee still remained. This was largely stored in Germany and was not settled for until 1918 but, it is claimed, the Government eventually made a profit on the whole transaction, although the method of accounting is considered by some to have been open to question.[7] The second valorization was even more successful; the Government bought at low prices and sold later at high prices. The period of the third valorization was that of 1921-24. The Federal Government then took control,[8] but had gradually been edging its way into this problem attracted, no doubt, by the success that had attended the efforts of the Sao Paulo Government and also to make available the advantages of the plan to other States. The Sao Paulo Government probably welcomed support. Moreover, coffee is the chief exportable commodity and affects foreign exchange. A change in policy was effected in that the storage of coffee was arranged at Brazilian ports rather than in European centres. The price stabilization feature was thus emphasized.

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[4] Rowe, J. W.F. Studies in the artificial control of raw material supplies, No. 3, Brazilian Coffee, Memorandum No. 34, Royal Economic Society, London, pp. 6.

[5] Rowe, J. W. F. Studies in the artificial control of raw material supplies, No. 3, Brazilian Coffee, pp. 7, Royal Economics Society, London.

[6] Wallace B. J., and Edminster, L. R. International control of raw materials, p. 128.

[7] Rowe, J. W. F. Studies in the artificial control of raw material supplies, No. 3, Brazilian Coffee, pp. 9, Royal Economics Society, London.

[8] A Federal Government loan of paper money was made to the Government of Sao Paulo in 1917. Profits from valorization were to be divided equally.

In 1922 there was an effort to establish "a permanent Institute for the Defense of Coffee" and so develop a permanent policy of valorization. Growers were to become responsible for storage and the regulation of supply was to be the paramount issue. The new scheme began to operate in 1925 and storage facilities were provided in the interior. However, surpluses increased until in 1929 there was again a year's production on hand. Moreover, new planting has been proceeding rapidly. The large crop of 1927-28 had resulted in extension of credit on the basis of coffee values and prospects. Planters were well off; a trade boom resulted and over-extension of credit followed. The financing of stocks of coffee became more difficult for the Sao Paulo banks. Therefore, early in 1930 a loan of twenty million pounds was obtained from international bankers to provide for liquidation of this surplus over a ten-year period. An additional export tax of approximately 73 cents per bag was added to secure this loan. But at the end of the year stocks had not diminished and prices were falling, therefore the Federal Government announced that it would purchase all excess stock as at June 30th, 1931. This was exclusive of the stock required to secure the loan just referred to. Entries to the ports were to be free only so long as they did not exceed one-twenty-fourth of the crop commenced and the crop immediately following. A tax equivalent to six and one-half cents per tree per annum on new plantings other than replacement during a term of five years was provided as well as a tax in kind of all coffee amounting to 20%.

Then a little later an agreement was reached between the Federal and State Governments whereby the States were to collect a special tax equivalent to approximately $2.43 per bag and deposit their collections to the account of the National Coffee Council daily, to be used exclusively "in the purchase for elimination of the excess of production and of the actual stocks for the purpose of balancing supply and demand . . . ." Destruction of surplus stocks by burning began in June 1931 and was reported to be taking place at the rate of one million bags per month. In addition to these steps the Federal Government issued a decree in December 1931 raising the export surtax to the equivalent of $3.65 (U.S. exchange) per bag, and the Sao Paulo tax of 3s. was abolished. The National Coffee Council was given power to enter into market operations; funds were provided through the Bank of Brazil. In May 1932 the export tax was advanced to the equivalent of $4.20 per bag but it was subsequently reduced to $3.74 per bag. Late in 1932 a decree was issued prohibiting the planting of coffee fields during the next three years and an export quota was established.

The Federal Government took complete control of coffee defense in February 1933 when the National Coffee Department was established under the Department of Finance and the programme appeared to be that of purchase and storage of the equivalent of one year's crop, destruction by burning at the rate of 750,000 bags per month and restriction of exports through the application of an export tax of 50 per cent ad valorem. Efforts are also being made through trade agreements to secure better markets for surplus coffee.[9]

In the coffee valorization scheme there appear, therefore, several factors among which are: (1) an export surtax; (2) restriction of entries of coffee to export ports; (3) provision for a tax on new plantings other than replacements; (4) purchases for holding off the market; (5) destruction of surplus stocks; (6) dependence in a large measure on foreign credit.

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[9] Lynsky, Meyer. Agricultural price supporting measures. Bulletin of the Pan American Union, July 1933, pp. 569, 572-73.

# BUSINESS ANALYSIS OF THE COMBINED OPERATIONS OF TWENTY-FIVE CO-OPERATIVE DAIRY COMPANIES IN CANADA[1]

A. E. Richards[2]

The oldest co-operative dairy on the Economics Branch records which is still engaged in active business is the Stanley Bridge Dairying Company at Stanley Bridge, Prince Edward Island, established in the year 1885. For the past forty-eight years this company has been manufacturing cheese and butter and conducting a business on the co-operative plan. In the same province five years later, the Hamilton Cheese Factory which is affiliated with the Kensington Dairying Association commenced business, and by 1900 there were eleven co-operative dairy factories on the Island serving their farmer patrons. It is regretted that our records do not associate the name of the founder with this early development of co-operation on Prince Edward Island. Co-incident with this development, or shortly after, co-operative dairies were established in other provinces, and to-day are performing a useful service for their farmer patrons throughout the Dominion.

Returns were received from 113 co-operative dairy plants in 1932 in connection with the economic survey of marketing activities of farmers' business organizations throughout Canada. These companies have assets totalling $3,898,060 with a combined membership of 27,524 producer shareholders. Total business for the year ending December 31, 1931, amounted to $15,444,833. Returns from individual companies are classified, tabulated and analysed. Financial statements are reduced to operating percentages which permit comparisons among companies of similar type on a common basis. Certain ratio tests are then applied indicative of soundness and efficiency.

Tables 1 and 2 show the combined statements of twenty-five co-operative dairy companies selected from six provinces in Canada. The balance sheet and operating percentages have been worked out for each company and are made available to individual companies for comparison with the average and with other companies. An analysis of this kind shows great variation among companies and certain weaknesses in financial structure and management are brought to the surface. Each of the twenty-five companies is separately owned and controlled. In this "set up" they are combined as one organization in order to give a representative picture of the financial status of co-operative dairying in Canada. On the whole, as brought out in these tables the dairy co-operatives in Canada seem to be in a reasonably sound position and are withstanding the present economic strain in an encouraging manner. It should be borne in mind however, that this analysis applies to only one year and, therefore, cannot be conclusive. Balance sheets are changing, and every day of business brings about a new alignment in the relative position of the items. For that reason balance sheets applicable to the business covering a number of years are necessary to properly evaluate any business and determine whether it is making progress or slipping back. Succeeding years will, therefore, increase the value of statistics which farmers organizations supply to the Economics Branch for study and analysis. Without this information conclusions cannot satisfactorily be drawn or standard ratios determined. It is hoped, however, that the analysis may be of value to individual companies who can use the ratios as checks to determine their status in relation to the average of all.

*The Balance Sheet.*—An examination of the balance sheet, Table 1, shows that current assets amount to $1,619,527 and current liabilities $910,633 or expressed as a ratio 1.78 to 1. This is known as the current ratio. Considered as a single business this would mean that the organization had $1.78 of readily convertible assets covering each $1.00 of current indebtedness. A ratio of 2 to 1 is generally looked upon as a desirable standard for many types of business. Among the twenty-five companies in this group some had current ratios as high as 8 to 1 while others showed up rather poorly with only 45 cents of liquid assets for each $1.00 of current liabilities.

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[1] This article deals with a section of a Report on Farmers' Business Organization in Canada in the course of preparation by the Agricultural Economics Branch.

[2] Agricultural Economist, Department of Agriculture, Ottawa.

TABLE 1.—COMBINED BALANCE SHEETS OF TWENTY-FIVE CO-OPERATIVE DAIRY COMPANIES AS AT DECEMBER 31, 1931

| | $ | % |
|---|---|---|
| Assets: | | |
| Current Assets: | | |
| Cash on hand and in bank | 70,095 | 2.5 |
| Accounts and notes receivable | 655,791 | 23.1 |
| Merchandise inventory | 323,896 | 11.4 |
| Other | 569,745 | 20.0 |
| Total current assets | 1,619,527 | 57.0 |
| Fixed Assets: | | |
| Plant, less depreciation | 1,163,948 | 41.0 |
| Other | 55,929 | 2.0 |
| Total fixed assets | 1,219,877 | 43.0 |
| Total assets | 2,839,404 | 100.0 |
| Liabilities and Net Worth | | |
| Accounts payable. | 256,331 | 9.0 |
| Bank loans | 30,459 | 1.1 |
| Accrued expenses | 20,369 | 0.7 |
| Other | 603,474 | 21.3 |
| Total current liabilities | 910,633 | 32.1 |
| Mortgages | 89,090 | 3.1 |
| Other | 164,335 | 5.8 |
| Total fixed liabilities | 253,425 | 8.9 |
| Net Worth: | | |
| Capital Stock | 1,098,074 | 38.7 |
| Reserve, general | 22,755 | 0.8 |
| Reserve for contingencies | 116,066 | 4.1 |
| Other | 328,853 | 11.6 |
| Surplus | 109,598 | 3.8 |
| Total net worth | 1,675,346 | 59.0 |
| Total liabilities and net worth | 2,839,404 | 100.0 |

Accounts and notes receivable are a rather large item amounting to $655,791 or 23.1% of total assets. This indicates a fairly free extension of credit among some companies which have accounts owing them as high as 50% of all assets. The merchandise inventory consists mainly of stocks on hand made up of butter, cheese and other milk products. Expressed as a percentage of total sales this amounts to only 4.9%. The combined value of plant and equipment including real estate amounted to $1,163,948, less allowance for depreciation, or 41.0% of total assets.

Current debt of $910,633 is fairly well covered by immediately convertible assets of $1,619,527. Long term debt and mortgages of $253,425 becomes a drag on the business unless it is systematically reduced. The 8.9% average is not serious but for a few individual companies it runs as high as 50% of total liabilities and net worth.

Paid up capital stock totalling $1,098,074 represents direct investment of 15,538 shareholders in the business or an average investment of $71.59. Shareholding privileges in most companies are limited to producer patrons. For the majority of the dairy companies, the par value of the shares is $10.00 or $25.00.

*Net Worth and Debt.*—The total net worth which represents the capital provided by members to their business is $1,675,346 or 50% of the total liabilities and net worth. This is a satisfactory position, although some companies drop as low as 20%. For others this percentage exceeds 80%. The worth to debt ratio shown in Table 3 is significant and considered as important as the current ratio in business analysis. In this business it stands 1.44 to 1 which means that ownership is within the business-

TABLE 2.—COMBINED OPERATING STATEMENTS OF TWENTY-FIVE CO-OPERATIVE DAIRY COMPANIES FOR YEAR ENDING DECEMBER 31, 1931

| | $ | % of Total Business | % of Gross Margin |
|---|---|---|---|
| Total business | 6,786,598 | 100.00 | |
| Sales of farm products | 6,573,128 | 96.86 | |
| Paid to producers | 4,440,290 | 65.43 | |
| Gross margin | 2,132,838 | 31.43 | |
| Sales of merchandise | 149,512 | 2.20 | |
| Cost of merchandise | 138,660 | 2.04 | |
| Gross margin | 10,852 | 0.16 | |
| Other receipts | 63,958 | 0.94 | |
| Total gross margin | 2,207,648 | 32.53 | 100.00 |
| EXPENSES: | | | |
| Wages and salaries | 503,025 | 7.41 | 22.79 |
| Rental | 11,522 | 0.17 | 0.52 |
| Depreciation | 95,475 | 1.41 | 4.32 |
| Supplies | 18,362 | 0.27 | 0.83 |
| Insurance | 10,935 | 0.16 | 0.50 |
| Taxes | 2,880 | 0.05 | 0.13 |
| Advertising | 3,536 | 0.05 | 0.16 |
| Interest on borrowed money | 5,573 | 0 08 | 0.25 |
| Plant maintenance | 982,835 | 14 48 | 44.52 |
| Other | 314,208 | 4 63 | 14.23 |
| Total expenses | 1,948,351 | 28 71 | 88.25 |
| Net operating income | 259,297 | 3.82 | 11.75 |
| Other income | 3,799 | 0 06 | 0.17 |
| Net income for distribution | 263,096 | 3.88 | 11.92 |
| DISPOSITION OF SURPLUS: | | | |
| Dividends | 71,999 | 1.06 | 3 26 |
| Patronage refund | 37,467 | 0.55 | 1.70 |
| Carried to reserve | 95,681 | 1.41 | 4.33 |
| Total | 205,147 | 3.02 | 9.29 |
| Undivided income | 57,949 | 0.86 | 2 63 |

and members' interests exceed outside interest by nearly 50%. Some companies show a much stronger position; others are less happily situated with debt exceeding worth.

*Business and Plant Value.*—The ratio of business to plant value is indicative of plant efficiency. Again considering the combined operations as those of one large company the ratio means that the company did $5.83 worth of business for each $1.00 in plant and equipment. Three plants in the survey exceeded $10.00 of business for each $1.00 of plant value while six companies dropped below $2.00 of business for $1.00 of plant value. A ratio as low as 2 to 1 suggests a low volume of business in relation to the capacity of the plant. This may be due to lack of patronage or falling production but too often the reason lies in over-expansion of plant and equipment in relation to volume of butter-fat. In certain instances the members have been "oversold" on expensive and elaborate equipment.

Net worth may be accompanied by reasonable investment in fixed assets. If the fixed assets exceed net worth to an unreasonable degree the ratio is out of proportion and the company is said to be over-invested in plant. The ratio net worth to fixed assets for this composite group is 1.37 to 1, although in six plants fixed assets are considerably in excess of net worth and the ratio stands about 0.5 to 1. Working capital is the excess of current assets over current liabilities. For the group, net working capital amounts to $708,894 which is 24.97% of total assets.

*The Operating Statement.*—The operating statement shows that the total business of the twenty-five companies grouped together amounted to $6,786,598. This is made up of sales of farm dairy products amounting to $6,573,128 or 96.86% of the total business. Sales of merchandise by these companies which include feeds, fertilizer, farm implements, etc., amount to only $149,512 or 2.20% of the total. Other receipts of $63,958 made up of revenue from storage, credits, etc., amount to 0.94%.

Out of the $6,573,128 which was obtained by the companies from the sale of milk, butter and cheese the producer patrons were paid $4,440,290 or 68 cents on each dollar of sales. Merchandise which cost $138,660 was sold to producer patrons for $149,512 at a margin of profit of 7.8%. Altogether the companies had a margin of over 2 millions or 32.33% of total business out of which to pay operating expenses. Among individual companies variations in gross margins are to be found ranging all the way from 40% down to 15%.

One of the large items of expense is wages and salaries which accounts for 22.79% of total expenses. Taxes and insurance combined use up less than 1%, and less than 0.25% is devoted to advertising expense. Plant maintenance is a large item. Total expenses were 88.25% of the gross margin which leaves a balance of 11.75. This along with other income of 0.17 derived from invested funds, etc., gives 11.92% or nearly one-eighth of the gross margin to be returned to producers as patronage refunds put into reserves or paid out as dividends on stock.

TABLE 3.—RATIO TESTS APPLIED TO THE COMBINED OPERATIONS OF TWENTY-FIVE DAIRY COMPANIES IN CANADA FOR YEAR 1931

| | |
|---|---|
| Current assets to current liabilities | 1.78 to 1. |
| Worth to debt | 1.44 to 1. |
| Business to plant value | 5.83 to 1. |
| Net worth to fixed assets | 1.37 to 1. |
| Per cent working capital of total assets | 24.97 |
| Per cent expenses of business | 28.71 |
| Business per employee | $15,968 |
| Business per patron | $363 |

All of these companies follow the co-operative principle in the disposition of surplus. The Acts of Incorporation in the majority of the provinces govern the apportionment of the surplus. Usually not less than 10% of the net surplus must be set aside for a reserve fund until an amount has accumulated in the fund equal to at least 35% of the paid-up capital stock. Interest is allowed on paid-up capital stock at a rate varying from 6 to 8%. The remainder is then divided among the patrons and shareholders in proportion to the volume of business which they have done with the Association.

*Distribution of Net Income.*—Out of a net income of $263,096 for distribution the amount carried to reserve for these companies was $95,681 or 36.4%. Interest on paid-up stock held by shareholders amounted to $71,999 which is equivalent to a dividend of 6.5%. The sum of $37,467 was refunded to patrons who contributed to the business and the remainder, $57,949, was left in the undivided income account.

These dairy companies as a group employed 425 persons including management and labour. Salaries and wages averaged $1,183.59 for each employee for the year. An interesting factor in the analysis is the business per employee which for all companies averaged $15,963 for the year. For some companies this exceeded $20,000, for others it dropped as low as $3,000 which would suggest in the latter instance that labour was not employed to full advantage.

Patrons numbered 18,675 and each contributed on the average $363 of business. This item varied all the way from over $4,000 to less than $100. This variation is largely dependent on the degree of specialization in dairying among patrons of the creamery. For many patrons dairying is a side-line enterprise on their farms.

# COST OF TRACTOR OPERATION ON PRAIRIE FARMS IN WESTERN CANADA[1]

E. G. GREST[2]

A large portion of the farm power for field work which was formerly supplied by horses in Western Canada is now supplied by tractors of various makes and sizes Horses, however, are still the most important source of draught power and will probably hold this place for some years to come. There is a place for both types of draught power on the farms. The chief difficulty is to adjust the power requirements to the size of the farm. A knowledge of tractor costs and the size of farm and hours of use required for economic utilization should, therefore, aid farmers in making proper adjustments.

TABLE 1.—TRACTOR OPERATING COSTS PER TRACTOR AND PER HOUR, SASKATCHEWAN AND ALBERTA

| Costs for Year Ending April 1, 1931 | Size of Tractor | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Two-plow | | Three-plow | | Four-plow | | Five-plow | |
| Number of tractors | 23 | | 149 | | 77 | | 7 | |
| Average hours operated, 1930 | 246 | | 417 | | 482 | | 386 | |
| Average value | $373 | | $842 | | $984 | | $831 | |
| Average size of farm, acres of land | 376 | | 583 | | 706 | | 771 | |
| | Per Tractor | Per Hour | Per Tractor | Per Hour | Per Tractor | Per Hour | Per Tractor | Per Hour |
| Gallons of fuel used | | 1.90 | | 2.41 | | 2.84 | | 3.21 |
| Cost of fuel | | $0.51 | | $0.65 | | $0.77 | | $0.89 |
| Gallons of cylinder oil | | 0.08 | | 0.10 | | 0.12 | | 0.21 |
| Cost of cylinder oil | | $0.09 | | $0.11 | | $0.15 | | $0.24 |
| Cost of grease | | $0.01 | | $0.01 | | $0.01 | | $0.02 |
| Parts, plus hired labour, repairing* | | $0.06 | | $0.04 | | $0.06 | | $0.22 |
| | $ | $ | $ | $ | $ | $ | $ | $ |
| Total cash costs | 166.0 | 0.67 | 336.5 | 0.81 | 479.6 | 0.99 | 529.4 | 1.37 |
| Interest at 6% | 22.4 | 0.09 | 50.5 | 0.12 | 59.1 | 0.12 | 49.9 | 0.13 |
| Depreciation | 78.0 | 0.32 | 159.7 | 0.38 | 190.9 | 0.40 | 163.7 | 0.42 |
| Value of servicing, overhauling | 11.5 | 0.05 | 27.6 | 0.07 | 32.5 | 0.07 | 37.0 | 0.10 |
| Hours servicing overhauling | 33.9 | 0.14 | 67.7 | 0.16 | 78.2 | 0.16 | 65.6 | 0.17 |
| Total operating costs | $277.9 | $1.13 | $574.3 | $1.38 | $762.1 | $1.58 | $780.0 | $2.02 |
| Per cent cash costs are of total | | 59 | | 59 | | 62 | | 68 |

*Hired labour repairing equals less than one-half of a cent per hour for the two, three and four-plow tractors and equals four cents per hour for the five-plow tractors.

The following discussion is based upon an analysis of the operation of 256 tractors of the modern type which are used for nearly all kinds of field and belt power purposes on farms in Western Canada. For purposes of comparison tractors were classified according to the number of plows they were drawing on the farms visited. Thus, there were four classifications—two-plow, three-plow, four-plow and five-plow tractors.

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[1] The data used in this article were collected during the summer of 1931 in the Olds, Bow Island, Foremost, Hilda and Irvine districts in Alberta and at Davidson, Craik, Maple Creek and Richmond in Saskatchewan. The study was conducted co-operatively by the Canadian Pioneer Problems Committee, the Department of Farm Management of the University of Saskatchewan, the University of Alberta and the Agricultural Economics Branch of the Federal Department of Agriculture.

Preliminary statement, subject to revision and correction. This summary was prepared from the original manuscript by C. V. Parker, Field Assistant, Agricultural Economics Branch, Ottawa.

[2] Formerly Field Assistant, Agricultural Economics Branch, now registered in the Graduate School, University of Minnesota, as Saskatchewan Research Foundation Fellow.

Details of the costs of operation per tractor and per hour for tractors of different sizes are presented in Table 1. The bulk of the fuel used was gasoline while some kerosene and small quantities of distillate were also used. The average price paid for gasoline after deducting the rebate on the "gas tax" was 27 cents per gallon.

The cash costs of tractor operations varied from 59% to 68% of the total cost of operation; for the three-plow tractor—the most popular size in use—this figure was 59%. Three-plow tractors were operated 417 hours per year on the average and were found on farms with an average crop area of 583 acres. The cash costs for the year were $336.50 per tractor or an average of 81 cents per hour. Total operating costs, including interest, depreciation and servicing amounted to $574.30 per year or $1.38 per hour. The average cost per hour of the main items of expense were: fuel 65 cents; lubricating oil 11 cents; grease 1 cent; parts and hired labour for servicing 6 cents; interest 12 cents; depreciation 38 cents; and value of servicing and overhauling 7 cents per hour.

The consumption of fuel for three-plow tractors averaged 2.41 gallons per hour, while that of lubricating oil averaged one-tenth of a gallon per hour. Figures for other sizes of tractors are also presented in Table 1.

TABLE 2.—HOURS OPERATED PER YEAR AS RELATED TO TOTAL COST OF OPERATING TRACTORS PER HOUR

| Hours Operated per Year | Size of Tractor | | | | | |
|---|---|---|---|---|---|---|
| | Three-plow | | | Four-plow | | |
| | Number | Average Hours Operated | Power Cost per Hour | Number | Average Hours Operated | Power Cost per Hour |
| 1 - 199 | 34 | 117 | $2.31 | 8 | 148 | $2.45 |
| 200 - 399 | 47 | 305 | 1.59 | 25 | 324 | 1.76 |
| 400 - 599 | 33 | 484 | 1.30 | 24 | 507 | 1.52 |
| 600 and over | 35 | 794 | 1.17 | 20 | 781 | 1.47 |
| All tractors | 149 | 417 | 1.38 | 77 | 482 | 1.58 |

*Hours Used and Cost per Hour.*—The cost per hour of tractor operation is influenced greatly by the number of hours worked as shown by data presented in Table 2. For three-plow tractors when the hours used increased from an average of 117 per tractor to 794, the cost per hour decreased from $2.31 to $1.17. Similarly, a decrease in cost from $2.45 to $1.47 per hour was recorded for four-plow tractors. A considerable amount of the overhead charges remained constant regardless of the number of hours tractors were used, and, therefore, they form a greater proportion of the total cost when tractors were used for a small number of hours. For this reason it is doubtful if the purchase of a tractor is a wise investment on a farm in Western Canada unless at least 500 hours of effective work are available for it on the owner's farm.

*Size of Farm and Hours of Tractor Use.*—The size of farm required to give 500 hours of effective tractor work during the year depends on the proportion of the total field work done by the tractor and also on the intensity of farming carried on.

Assuming that tractors would do all the field work, it was found that the size of farm required to enable economical usage of tractor power in all the districts studied was as follows: two-plow tractor—one-half to three-quarters of a section, assuming each quarter section has 140 to 150 acres of cropland; three-plow tractor—three-quarters to one and one-quarter sections; four-plow tractor—from one to one and one-half sections. If horse power is to be used in conjunction with tractor power then an allowance of from 30 to 50 acres of cropland per work horse must be made in the above acreages.

TABLE 3.—COST OF DOING VARIOUS OPERATIONS OF FIELD WORK WITH 3-PLOW TRACTOR POWER

| | Spring & Fall Plowing | Cultivating | Seeding | Double Discing | Harrowing | Cutting |
|---|---|---|---|---|---|---|
| Number of outfits | 86 | 25 | 32 | 93 | 15 | 21 |
| Common size of implement | 3-14″G | 12′ | 14′ | 10′T | 32′ | 10′ |
| Acreage per outfit hour | 1.24 | 3 66 | 4 22 | 3.21 | 9.90 | 3.01 |
| | $ | $ | $ | $ | $ | $ |
| Average cost per acre, 1930: | | | | | | |
| Cost of draught power | 1 12 | 0 38 | 0.33 | 0 43 | 0.14 | 0 46 |
| Cost of man labour | 0.33 | 0.11 | 0.09 | 0.13 | 0.04 | 0.22 |
| Total cost | 1 45 | 0.49 | 0.42 | 0.56 | 0.18 | 0.68 |
| | $ | $ | $ | $ | $ | $ |
| Estimated average cost per acre 1932: | | | | | | |
| Cost of draught power | 1.12 | 0.38 | 0.33 | 0.43 | 0.14 | 0.46 |
| Cost of man labour | 0.22 | 0.07 | 0.06 | 0.09 | 0.03 | 0.14 |
| Total cost | 1.34 | 0.45 | 0.39 | 0.52 | 0.17 | 0.60 |

*Field Work Costs per Acre.*—The cost of doing some of the major field operations with a three-plow tractor is presented in Table 3. The costs per acre in 1930 were: plowing $1.45, cultivating 49 cents, seeding 42 cents, double discing 56 cents, harrowing 18 cents and cutting 68 cents. In 1932 there was a reduction of about 33% in labour costs but operating expenses remained the same as in 1930. The three-plow tractor was the most common size in use, and on the average it performed field work nearly as cheaply as the four-plow and more cheaply than the two-plow tractor. Theoretically, the four-plow tractor should do field work more cheaply because of the saving in man labour costs per acre, but in many cases they were pulling implements of sizes recommended for three-plow tractors. Tractors of all sizes were commonly underloaded, thus resulting in inefficient use of power.

*Comparison with Horse Costs.*—It was found that the cost of doing major field operations was less with tractors than with horses in 1930. By 1932, however, feed prices and labour costs had decreased so much, while cash costs of tractor operation remained practically the same, that horse power was found to be much more economical than that of the tractor. As a general rule the total cost of doing field operations with horses will be less than with tractors when it requires more than 2 bushels of oats to purchase enough fuel to operate a three-plow tractor for one hour.

## ECONOMIC LITERATURE

RUSSEL, SIR E. JOHN. THE FARM AND THE NATION. George Allen and Urwin Limited, Publishers, Museum Street, London, 1933, p. 240.

The author of this book, Sir E. John Russel, is Director of the Rothamstead Experimental Station. The book is of direct interest to those people in Canada as well as those in Great Britain who are interested in agricultural problems and the shaping of adequate policies to deal with them.

The first chapter of the book is entitled "The Nation's Food; From Whence Does It Come? " Herein the question is presented, "Is this the best way of using our national wealth, or should we do better to produce more of the food ourselves?" The chapters following are devoted to an answer to this query. Chapter II gives a resume of the "Ups And Downs Of British Agriculture". The author presents an historical review of the trends in British agriculture from very early times down to the present. In Chapter III "Our Farming Land, How We Use It", the author gives an enlightening description of the agricultural areas of Great Britain, the soil types, topography, historical changes and present land utilization. "The Result Of Our Agricultural Efforts" forms the basis of discussion in Chapter IV. The thirty million acres of cultivated land in Great Britain, together with imported animal foods produce 40% of the food supplies for forty-five millions of people (1⅓ acres, plus imported animal food, feed one person).

Chapters V and VI deal with the Empire as a source of food, and the possibility of increasing the Empire's share of the total imports. Of the 60% of the food imported the Empire sends 21% and foreign countries 39%. Summing up the findings of Chapters V and VI the author states, "We could without difficulty set up all British supplies of milk, potatoes, lamb, mutton and cheese . . . . for bread and fruit we could be nearly self-sufficing but probably not quite . . . . beef, bacon, butter and eggs it would be difficult but not impossible to become self-sufficient." But the question is raised, "Should we go out of our way to close our markets to them (foreign countries)? "

Some of the farmer's difficulties are presented in Chapter VII. In agriculture, production is slow and cannot be hastened, thus adjustments to price changes are difficult to bring about. Farmers are defeated by falling prices because they cannot change their activities quickly enough. Falling prices cannot be met by reduced wages because of the minimum wage law. In Chapter VIII ways of using the agricultural lands of Great Britain are discussed. Lastly, in Chapter IX the question of displaced men in relation to agriculture is dealt with.

The author concludes by stating that there are three ways in which British agriculture could be treated; it could be "(1) organized for the production from our own soil of as much food as is possible; (2) organized for the provision of work for men displaced by modern methods and by machinery; (3) left to struggle as best it can against unrestricted imports of food from overseas, the farmer being entirely free to gain any possible profit for those working on the land regardless of the total amount of wealth produced."

"These three are entirely distinct and are in the main incompatible . . . . The production of the maximum amount of food necessitates protecting the farmer against risk of falling prices during the period of growth." This would involve a contract system with agreed prices or a quota system. "The result of unrestricted imports from overseas is to compel farmers to reduce costs of production, and they do it by reducing labour. Until recently men so displaced have gone overseas or found work in towns . . . . the saving in cost of food affected by displacing these men has therefore to be offset by the cost of supporting them in idleness or non-productive work."

"It is possible by means of small holdings and family farms to find work on the land for some of the men displaced from agriculture and from industry. This would somewhat counterbalance the exodus of men from farms because of enlargement and mechanization of holdings. Small farms, however, are costly to establish, difficult to run successfully and require longer hours and harder work from the operator and his family."

"There seem to be possibilities in the establishment on the land of communities that are largely self-sufficing, . . . . provided with modern implements to obviate the hardships . . . ."

"The decision between these various possibilities should be made quickly and definitely; the problems will only grow worse with delay."

WELLS, ORIS V. FARMERS RESPONSE TO PRICE IN HOG PRODUCTION. Technical Bulletin, No. 539, United States Department of Agriculture, Government Printing Office, Washington, D.C.

The author's purpose in this bulletin "was to obtain a more complete explanation of the farmers' response to price in hog production and marketing and to develop a simple statistical analysis of the available post-war data which may be easily reworked or extended." In the past, studies of the producer's response to price in hog production have been made from a collective or mass response view point. In the present study the author goes a step further and analyses the responses of individual farmers to price changes.

The findings of other workers were substantiated in this bulletin for it was found that ". . . . farmers increase or decrease their hog production and subsequent marketings from year to year in response to the corn-and-hog price situation (which is best measured by the corn-hog ratio, i.e. the number of bushels of corn required to buy 100 pounds of live hogs) the same year and one year before the change in production is made."

The author also found that the same general type of analysis which will explain the variation in the total United States hog production will also explain the variation in hog production within an individual market district, a state or a broad type of farming area. Hog production response differs slightly in the various sections. "In the last decade it has been made to the corn-hog ratio in the corn belt. In the dairy section it has been modified by the skim milk situation. On the Pacific Coast, the response has been more nearly made to the barley-hog than to the corn-hog ratio. In the South, the response has been directly related to the acreage of corn and is indirectly related to the price of cotton." "So long as the majority of hog producers continue to respond to the corn-hog ratio and feed-supply situation in the future as in the past, the prospective hog-supply situation can be forecast, and the individual producers can profit by adjusting their hog production with reference to the hog-price outlook relative to the price outlook for such alternative enterprises as may be open to them."

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## NOTES

A release from the Census and Vital Statistics Branch of the Dominion Bureau of Statistics based on the 1931 census shows that there were 197,204 male wage earners and 1,800 female wage earners engaged in agriculture in 1931. The average earnings of those reporting were $319 per year for the male employees and $275 for the females. The male workers were employed on the average of 43.56 weeks of the year and female workers, 43.83 weeks. The average earnings of male employees were $927 per year in all industries and for female wage earners $560. Male employees were, on the average, employed 41.12 weeks while female wage earners were employed 46.59 weeks in 1931.

* * *

Officers of the Canadian Society of Agricultural Economics for 1933-34 are as follows: President—Dr. W. V. Longley, Agricultural College, Truro, Nova Scotia; Vice-President—H. C. Bois, Rural Economics Branch, Department of Agriculture, Quebec, P.Q.; Secretary—J. Coke, Economics Branch, Department of Agriculture, Ottawa; Executive Committee—Dr. T. W. Grindley, Dominion Bureau of Statistics, Ottawa, Dr. W. Allen, University of Saskatchewan, Saskatoon; H. R. Hare, Lower Mainland Milk Producers' Association, Vancouver; F. W. Reinoehl, Colonization Finance Corporation, Winnipeg.

* * *

T. G. Major, Tobacco Division, Central Experimental Farm, Ottawa, writing in "The Lighter", September 16th, in regard to Canadian tobacco in the United Kingdom, states, "On the whole the situation is reasonably satisfactory. It is important, however, that anything approaching the nature of a boom in production should be avoided. Only slow, steady development based on a product of increasingly better quality, will result in the permanent establishment of Canadian tobacco in the Old Country market."

* * *

A. Gosselin, Economics Branch, Department of Agriculture, Ottawa, and R. Lecuyer, Rural Economics Branch, Department of Agriculture, Quebec, have completed field work in connection with a study of the cost of producing apples in Quebec. Data have also been secured with regard to the cost of developing an orchard to bearing age.

* * *

The initial payment for pooled wheat will be 45 cents per bushel in store at Fort William, according to a statement recently issued by Saskatchewan Wheat Pool Officials.

* * *

The Okanagan Stabilization Board has been formed to direct the marketing of British Columbia fruit during the season of 1933-34. Major M. V. MacGuire, who was Manager for the Cartel Committee which operated last year, will be Manager for the new Committee.

* * *

The Ontario Milk Producer, September, 1933, reports milk prices in Ontario cities as follows: St. Catharines and Niagara Falls $1.81 per cwt.; Toronto, Hamilton and Oshawa $1.81; Kitchener $1.40; London $1.00 (since raised $1.40); St. Thomas $1.55; Sarnia $1.30; Windsor $1.40.

* * *

The Prince Edward Island Co-operative Live Stock Marketing Board was organized on August first. A constitution has been adopted by the Board of Directors. The new organization will handle shipments from 28 clubs on the Island.

# L'ECONOMISTE AGRICOLE

REVUE TRIMESTRIELLE DE L'INDUSTRIE AGRICOLE PREPARE PAR

LA DIVISION DE L'ECONOMIE AGRICOLE
MINISTERE FEDERAL DE L'AGRICULTURE
OTTAWA

Vol. III. Nos. 7, 8, 9. Juil., août., sept., 1933.

## LA SITUATION ECONOMIQUE

De 67.6 qu'il était en juin, l'indice des prix de gros au Canada, computé par le Bureau fédéral de la Statistique, est passé à 70.5 en juillet. En août, léger fléchissement des prix et baisse de l'indice à 69.4, causés principalement par l'avilissement des végétaux dont l'indice est tombé de 69.8 à 65.7. Il y a eu également une légère réaction dans les métaux non ferreux et leurs produits.

*Prix de détail.*—En mai les prix de détail atteignaient le bas point de 77.0, qu'ils ont maintenu en juin. L'indice de juillet est monté d'une fraction, celui d'août s'est élevé assez brusquement à 78.6, principalement à cause des denrées alimentaires et du combustible, l'indice des premières ayant passé de 63.2 en juillet à 67.8 en août. Une revision du groupe des produits divers, publiée par le Bureau fédéral de la Statistique, a entraîné une revision de l'indice total des prix de détail.

*Embauchage.*—L'indice de l'embauchage est passé de 87.5 en juillet à 88.5 en août. Après correction pour la saison les chiffres respectifs étaient de 83.0 et 84.8. Les maisons qui soumettent des rapports réguliers disent avoir remis au travail 116,000 personnes pendant les cinq mois du 1er avril au 31 août.

*Volume physique des affaires.*—Le volume physique des affaires a continué à augmenter en août, l'indice passant de 84.1 en juillet à 89.8 en août, tandis que l'indice des produits industriels montait de 84.1 à 89.5. Il y a eu gain considérable dans la production minérale, l'indice pour ce groupe passant de 78.3 en juillet à 95.7 en août. Les industries manufacturières indiquaient également une amélioration considérable, l'indice s'élevant de 88.2 à 96.9. Seule, l'industrie du bâtiment a rétrogradé, de 34.0 à 25.5. La production de l'énergie électrique a augmenté.

*Produits agricoles.*—De 60.1 qu'il était en juillet, l'indice des prix de gros des produits de ferme canadiens est tombé à 57.0 en août, principalement à cause de la baisse des prix du grain, spécialement du blé, mais la situation des grains s'est quelque peu améliorée vers la fin d'août. Les prix des fruits et des légumes frais domestiques ont également baissé.

Par contre, l'indice des produits animaux est passé de 59.0 à 60.5. Cette augmentation doit être attribuée principalement à une hausse de prix sur les porcs et les veaux, parce que les prix des bovins et des agneaux ont diminué.

L'indice des ventes agricoles est passé de 136.3 à 197.2. Le mouvement du grain, qui est souvent peu considérable en août, a été supérieur à la normale, et l'indice des ventes de grain est monté à 224.6. D'autre part, les ventes de bestiaux ont fléchi, tombant de 81.2 à 74.5. Les expéditions de bovins ont diminué, les ventes d'agneaux étaient un peu inférieures à la normale, tandis que les expéditions de veaux étaient plus fortes. Il s'est vendu à peu près le même nombre de porcs qu'en juillet.

Les indices des produits frigorifiés indiquent très peu de changement en juillet et en août.

La Division des fruits estime que la récolte de pommes au Canada est de 16 pour cent plus forte que celle de l'année dernière. En Nouvelle-Ecosse, la production est évaluée à 1,846,000 barils, soit 75 pour cent de plus qu'en 1932. Au Nouveau-Brunswick la récolte est exactement la même que celle de l'année dernière, 40,000 barils.

## CHIFFRES-INDICES, ANNUELS ET MENSUELS, DES PRIX ET DE LA PRODUCTION COMPUTES PAR LE BUREAU FEDERAL DE LA STATISTIQUE

| Année | Prix de gros 1926 = 100 | | | | Prix de détail et coût des services (5) | Production (6) 1926 = 100 | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Tous produits (1) | Produits de ferme (2) | Produits des champs (3) | Produits animaux (4) | | Volume physique des affaires | Production industrielle | Ventes de produits agricoles | Produits en entrepôts froids |
| 1913 | 64 0 | 62 6 | 56 4 | 77 0 | 65 4 | | | | |
| 1914 | 65 5 | 69 2 | 64 9 | 79 0 | 66 0 | | | | |
| 1915 | 70 4 | 77 7 | 76 9 | 79 2 | 67 3 | | | | |
| 1916 | 84 3 | 89 7 | 88 4 | 92 3 | 72 5 | | | | |
| 1917 | 114 3 | 130 0 | 134 3 | 119 6 | 85 6 | | | | |
| 1918 | 127 4 | 132 9 | 132 0 | 134 7 | 97 4 | | | | |
| 1919 | 134 0 | 145 5 | 142 4 | 152 5 | 107 2 | 71 3 | 65 5 | 48 1 | 47 1 |
| 1920 | 155 9 | 161 6 | 166 5 | 149 9 | 124 2 | 75 0 | 69 9 | 52 6 | 94 2 |
| 1921 | 110 0 | 102 8 | 100 3 | 108 5 | 109 2 | 66 5 | 60 4 | 65 2 | 86 4 |
| 1922 | 97 3 | 86 7 | 81 3 | 99 1 | 100 0 | 79 1 | 76 9 | 82 6 | 82 8 |
| 1923 | 98 0 | 79 8 | 73 3 | 95 1 | 100 0 | 85 5 | 83 8 | 91 4 | 87 6 |
| 1924 | 99 4 | 87 0 | 82 6 | 97 2 | 98 0 | 84 6 | 82 4 | 102 5 | 114 9 |
| 1925 | 102 6 | 100 4 | 98 1 | 105 7 | 99 3 | 90 9 | 89 7 | 97 2 | 108 6 |
| 1926 | 100 0 | 100 0 | 100 0 | 100 0 | 100 0 | 100 0 | 100 0 | 100 9 | 100 0 |
| 1927 | 97 7 | 102 1 | 99 9 | 105 7 | 98 4 | 106 1 | 105 6 | 103 6 | 110 0 |
| 1928 | 96 4 | 100 7 | 92 6 | 114 3 | 98 9 | 117 3 | 117 8 | 146 7 | 112 8 |
| 1929 | 95 6 | 100 8 | 93 8 | 112 5 | 99 9 | 125 5 | 127 4 | 101 1 | 109 6 |
| 1930 | 86 6 | 82 3 | 70 0 | 102 9 | 99 2 | 109 5 | 108 0 | 103 0 | 128 4 |
| 1931 | 72 2 | 56 3 | 43 6 | 77 6 | 89 6 | 93 5 | 90 4 | 99 0 | 125 7 |
| 1932 | 66 7 | 48 4 | 41 1 | 60 7 | 81 4 | 78 7 | 74 0 | 114 3 | 120 1 |
| 1933 | | | | | | | | | |
| Jan. | 63 0 | 43 6 | 35 1 | 57 9 | 79 1 | 68 1 | 62 2 | 56 1 | 112 0 |
| Fév | 63 6 | 43 0 | 36 0 | 54 7 | 78 4 | 67 0 | 60 0 | 76 5 | 127 6 |
| Mars | 64 4 | 44 7 | 38 0 | 56 0 | 77 8 | 68 4 | 62 5 | 129 0 | 135 8 |
| Avril | 65 4 | 46 8 | 41 1 | 56 4 | 78 1 | 69 8 | 65 1 | 104 1 | 112 7 |
| Mai | 66 9 | 51 2 | 46 9 | 58 4 | 77 0 | 76 4 | 72 7 | 95 4 | 100 4 |
| Juin | 67 6 | 52 6 | 49 4 | 57 9 | 77 0 | 82 2 | 79 8 | 221 9 | 119 9 |
| Juillet | 70 5 | 60 1 | 60 8 | 59 0 | 77 2 | 84 1 | 82 6 | 221 9 | 119 9 |
| Août | 69 4 | 57 0 | 54 9 | 60 5 | 78 6 | 89 8 | 89 5 | 197 2 | 114 2 |

1 Voir Prix et Indices des prix, 1913-1928, pages 19-21, 270-289 et 1913-1931, page 15

2 Prix de gros des produits de ferme canadiens Voir Prix et Indices des Prix, 1913 1931, page 33, et miméographes mensuels 1932 et 1933

3. Prix de gros des grains, fruits et légumes

4 Prix de gros des animaux et des produits animaux

5 Y compris la nourriture le loyer, le combustible les vêtements et objets divers Voir Prix et Indices des prix, 1913-1928, pages 181-185, 290-293 1926 = 100

Prix et Indices des prix, 1913-1931, page 122, et miméographes mensuels, 1932-1933

6. Revue mensuelle de la statistique commerciale, page 8 et indices mensuels du volume physique des affaires au Canada. Supplément à la Revue mensuelle de la Statistique commerciale, novembre 1932

Dans le Québec, les derniers rapports indiquent que la récolte ne sera inférieure que de 2 pour cent à celle de l'année passée, soit 254,000 barils. La récolte de l'Ontario est de 15 pour cent supérieure à celle de l'année dernière, elle est évaluée à 1,064,000 barils. La Colombie-Britannique a une plus petite récolte cette année, évaluée à 4,182,000 caisses, soit 18 pour cent de moins qu'en 1932.

Pendant les sept mois finissant en juillet 1933, la production du beurre a dépassé de 2.1 pour cent celle de la même période en 1932. L'augmentation est évaluée à 11.1 pour cent dans l'Alberta, à 7.9 pour cent dans la Saskatchewan, 5.3 pour cent dans l'Ontario, 4.8 pour cent dans la Colombie-Britannique, 3.1 pour cent en Nouvelle-Ecosse et 3.2 pour cent dans l'Ile du Prince-Edouard. Il y a eu une très légère diminution dans le Nouveau-Brunswick et une diminution de 3.5 pour cent dans le Québec et 1.6 pour cent au Manitoba.

La production du fromage a été jusqu'ici à un niveau un peu plus bas qu'en 1933. Le nombre de meules (fromages) classées pendant la période allant du 28 novembre 1932 au 2 septembre 1933, a été de 763,659 contre 875,567 pendant les mêmes dates approximativement en 1931-32. En 1933, cependant, 93.87 pour cent des fromages ont été classés "Premiers" contre 92.89 pour cent en 1932.

Jusqu'à la fin de septembre de cette année, les ventes de bovins aux marchés publics du Canada se sont montées à 750,288 têtes contre 907,890 en 1932. Les ventes de moutons pendant la même période ont été de 298,347 contre 266,059 l'année dernière. Les ventes de veaux ont été de 237,345 dans les premiers neuf mois de 1932, contre 240,487 pendant la même période en 1933.

Pendant la même période en 1933, le nombre de porcs classés a été de 2,289,668 contre 2,313,841 en 1932. Ce chiffre comprend les expéditions directes aux salaisons.

## PUBLICATION REPRISE

La publication de l'Economiste Agricole sous forme mensuelle, commencée il y a deux ans et demi et continuée jusqu'au mois de juillet 1933, a dû être suspendue parce que les crédits mis à la disposition de cette Division, aussi bien que des autres Divisions du Gouvernement, ont été réduits. Nous avons soumis un questionnaire à tous ceux auxquels cette publication était adressée, en les priant d'exprimer leur opinion sur son utilité et de nous dire s'ils désiraient continuer à recevoir des renseignements de ce genre. Leur réponse nous confirme dans notre conviction que l'Economiste Agricole, par les renseignements économiques qu'il fournit, répond à un besoin réel.

Nous nous proposons donc de publier une édition trimestrielle, contenant 16 pages au lieu des douze pages de l'ancien numéro mensuel. La liste des abonnés a été revisée sur la base des réponses que nous avons reçues, et l'Economiste ne sera adressé à l'avenir qu'à ceux qui nous ont demandé de maintenir leur nom sur cette liste.

## TENTATIVES DE CONTROLE COMMERCIAL PAR DES COMMISSIONS GOUVERNEMENTALES OU DES ORGANISATIONS SOUTENUES PAR LE GOUVERNEMENT[1]

J. Coke[2]

Nous nous proposons dans cette série d'articles de discuter les mesures prises par les Gouvernements, spécialement au moyen de commissions, pour contrôler le commerce. Il est évident que ce sujet se prête à bien des opinions différentes. D'aucuns voudraient que le gouvernement se bornât à faire observer les contrats et la loi, à maintenir l'ordre et à défendre les routes commerciales, tandis que d'autres recommandent une large mesure de contrôle des affaires, et même de participation au commerce. Une étude approfondie des tentatives faites dans ces voies conduirait probablement à une modification de ces vues extrêmes.

L'intervention du gouvernement dans le commerce n'est pas nouvelle, mais la tendance à la réglementation et à la surveillance s'est relâchée pendant quelque temps au cours du dix-neuvième siècle. Elle s'est ranimée, cependant, pendant les dernières années du siècle. Il y a eu, par exemple, un mouvement bien net contre les monopoles. Au commencement de ce siècle, l'établissement au Canada de la Commission fédérale des chemins de fer, de la Commission fédérale du grain et la Loi des recherches sur les monopoles, qui augmente le contrôle du gouvernement sur les catégories et les types des produits agricoles et la surveillance des moyens de vente, indiquent tous une intervention gouvernementale dans les entreprises commerciales.

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[1] Basé principalement sur un travail lu devant la cinquième réunion de l'Association canadienne de la science politique tenue à Ottawa le 22 et le 23 mai 1933. L'original a été publié dans le rapport des délibérations de l'Association.

[2] Commissaire adjoint, Division de l'économie agricole, Ministère de l'agriculture, Ottawa.

D'autre part, la nécessité du contrôle en temps de guerre a provoqué une nouvelle extension de l'activité gouvernementale, non seulement dans notre pays mais dans beaucoup d'autres. La réglementation des prix pendant la guerre avait deux buts contradictoires: il s'agissait en premier lieu de stimuler le ravitaillement, sans s'inquiéter du prix de revient ou du bénéfice, tandis que le contrôle du coût de la vie, qui comprenait le rationnement, comportait une étude précise des frais et des bénéfices. La note dominante de ce contrôle était non seulement de conserver les approvisionnements, mais aussi d'éliminer les "profiteurs". On se souvient que les tentatives faites pour réglementer la vente du blé ont été combattues par bien des cultivateurs lorsque la question est venue sur le tapis pour la première fois au Canada; plus tard ces mêmes cultivateurs ont demandé le rétablissement d'un régime à peu près semblable. On peut donc prétendre que la politique du temps de guerre a exercé un effet sur les régimes de ventes pendant les années d'après-guerre, comme le prévoyaient certains économistes. Par exemple, en 1918, le Prof. Pigou écrivait—"La vaste expansion de contrôle gouvernemental dans la sphère économique, survenue pendant la guerre, est sans parallèle dans l'histoire du monde. Nul ne doute que dans la période difficile de transition qui suivra immédiatement la déclaration de la paix, il faudra conserver une partie de ce contrôle, mais la question est de savoir jusqu'à quel point un contrôle de ce genre peut être exercé permanemment dans les temps de paix, et là-dessus la controverse fait rage."[3]

Quelle qu'ait pu être cependant l'influence exercée par la politique du temps de guerre sur la politique du temps de paix, il est clair que lorsque des groupes d'individus voient une dégringolade subite des prix qu'ils ne peuvent enrayer, ils se tournent vers le gouvernement, dans l'espoir qu'il fera quelque chose.

Il est difficile de faire une classification exacte des systèmes de contrôle; une classification large entraîne nécessairement des répétitions parce que l'importance attachée à certains moyens varie ou que plusieurs moyens peuvent être englobés sous un même système. Cependant, tous conviendront, je crois, que la plupart de ces systèmes se rapportent à l'offre, quoique certains efforts pour augmenter la demande aient été notés. Toutefois, dans bien des cas, les systèmes que j'ai étudiés indiquent que l'objet principalement cherché est la distribution d'un surplus. Ceci s'applique spécialement à ces systèmes qui visent au contrôle des prix. Nous présenterons donc un résumé sommaire de certains types de contrôle exercés par le gouvernement ou avec son consentement.

*La valorisation du café au Brésil.*—La valorisation du café est intéressante, non seulement pour l'expérience elle-même mais aussi parce qu'il en est résulte ce que l'on croyait être alors une politique permanente. La valorisation comporte une hausse des prix[4], mais les circonstances dans lesquelles elle a été inaugurée exigent quelques explications. Normalement, le rendement du café par arbre varie beaucoup, suivant les conditions de température. Lorsque la saison est favorable la récolte est abondante, mais l'arbre s'affaiblit et produit beaucoup moins l'année suivante. Ces facteurs sont si intimement reliés que l'on ne peut compter avoir une grosse récolte que si les arbres sont en bon état et si le temps est favorable. L'objet de la valorisation n'est donc pas tant de contrôler les prix que de prévenir les effets des grosses et des petites récoltes, contrôle qui est peut-être plus important dans le cas du café que dans celui de quelques autres produits, parce que la consommation du café ne varie guère, quelles que soient les fluctuations de prix. "Parlant d'une façon générale, on peut dire que la consommation physique réelle ne varie que dans des proportions insignifiantes, quel que soit le prix du café vert, non seulement parce que le café est une boisson régulière, dans tous les pays où il est employé, mais aussi parce que le prix du café vert n'atteint pas le tiers du prix demandé au consommateur, et que les deux autres tiers, représentant les frais de distribution et de traitement, sont virtuellement fixés et immuables en ce qui concerne la courte période."[5] Dès 1902 une forte taxe avait été imposée sur les plantations nouvelles pour décourager l'expansion. La première valorisation eut lieu en 1905, la seconde en 1918 et la troisième en 1921.

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[3] Pigou, A. C., Government Control in War and Peace, Economic Journal, Vol. XXVIII, p. 363.

[4] Rowe, J. W. F., Studies in The Artificial Control of Raw Material Supplies, No. 3, Brazilian Coffee, Memorandum No. 34, Royal Economics Society, Londres, p. 6.

Ce système fut inauguré à la suite de l'accumulation de gros stocks de café, qui se montaient presque à la production d'une année. L'Etat de Sao Paulo se procura un emprunt en s'engageant à prendre des mesures pour restreindre la production et les exportations. On décréta donc qu'il y aurait une surtaxe d'environ 60c. par sac sur le café exporté et que les entrées de café dans le port de Santos seraient limitées à 50,000 sacs (132 livres par sac) chaque jour d'affaires.[6] Cette mesure fit diminuer les arrivages de café mais ne réussit pas à améliorer les cours; elle obligea en outre les propriétaires de plantations à conserver leur café malgré le manque de moyens d'entreposage. Le gouvernement décida alors d'acheter une partie de la récolte pour empêcher que le surplus ne soit jeté sur le marché. En août 1908, une loi fut promulguée portant la surtaxe de trois à cinq francs,-environ trois-quarts d'un cent par livre, outre le droit régulier d'exportation de neuf pour cent. La loi imposait également une surtaxe de vingt pour cent sur les exportations dépassant neuf millions de sacs pendant l'année de récolte 1908-09. Ces mesures inspirèrent confiance aux banquiers qui accordèrent le crédit nécessaire pour leur continuation. Un fait intéressant à noter c'est qu'en 1909 le gouvernement de Sao Paulo proposa de prélever une taxe de dix pour cent payable en espèces, c'est-à-dire en café, et de jeter ce café dans l'océan. Cette recommandation, qui avait cependant l'approbation des banquiers, ne fut pas mise à exécution, peut-être parce que les prix ce raffermirent. En 1914, il restait encore un surplus de trois millions de sacs de café, qui avaient été principalement entreposés en Allemagne et qui n'avaient été payés qu'en 1918, mais on dit que le gouvernement fit un bénéfice sur la transaction, quoique d'aucuns prétendent que le système de comptabilité prêtait à la critique[7]. La deuxième valorisation fut encore plus heureuse; le gouvernement acheta à bas prix et revendit à prix plus élevés. La période de la troisième valorisation fut celle de 1921-24. Le gouvernement fédéral prit alors le contrôle[8]; il était entré graduellement dans la lutte, attiré sans doute par le succès qui avait couronné les efforts du gouvernement de Sao Paulo et également pour faire connaître les avantages du système aux autres Etats. Il est probable que cet appui fut bien accueilli par le gouvernement de Sao Paulo, D'ailleurs, le café est le principal produit d'exportation et il affecte le change étranger. On modifia le système; on s'arrangea pour entreposer le café aux ports du Brésil plutôt que dans les centres européens. On revenait ainsi à la stabilisation des prix.

En 1922, il y eu une tentative d'établissement d'un "Institut permanent pour la défense du café", afin de développer une politique permanente de valorisation. Les producteurs étaient tenus responsables de l'entreposage, et la réglementation de l'offre devait être l'issue principale. Le nouveau système commença à fonctionner en 1925 et des facilités d'entreposage furent pourvues dans l'intérieur. Les surplus augmentèrent cependant, si bien qu'en 1929 on avait encore une année de production en magasin En outre, les nouvelles plantations s'étaient rapidement développées. La grande récolte de 1927 28 avait résulté en une extension du crédit, basé sur les prix du café et sur les prévisions. Les planteurs étaient à l'aise; le commerce était dans un état florissant et il y eut une surextension de crédit. Il devint de plus en plus difficile pour les banques de Sao Paulo de financer les stocks de café. On contracta donc chez les banquiers internationaux, au commencement de 1930, un emprunt de vingt millions de livres pour liquider ce surplus sur une période de dix ans. Une taxe supplémentaire d'exportation d'environ 73c. par sac fut ajoutée pour garantir cet emprunt. Mais à la fin de l'année les stocks n'avaient pas diminué et les prix tombaient, aussi le gouvernement fédéral annonça qu'il achèterait tout l'excès de stocks jusqu'au 30 juin 1931, en plus de la quantité nécessaire pour garantir l'emprunt que nous venons de mentionner. L'entrée au port devait être gratuite tant qu'elle ne dépassait pas un vingt-quatrième de la récolte commencée et de la récolte suivant immédiatement. Une taxe équivalant à six cents et demi par arbre et par an sur les nouvelles plantations autres que les remplacements pendant une période de cinq ans fut établie, ainsi qu'une taxe en espèces sur tout le café se montant à vingt pour cent.

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[5] Rowe, J. W. F., Studies In The Artificial Control of Raw Material Supplies, No. 3 Brazilian Coffee, p. 7, Royal Economics Society, Londres.

[6] Wallace, B. J, et Edminster, L. R. International Control of Raw Materials, p. 128.

[7] Rowe, J W. F., Studies In The Artificial Control of Raw Material Supplies, No. 3, Brazilian Coffee, p. 9, Royal Economics Society, Londres.

[8] Un emprunt d'argent de papier fut consenti par le gouvernement fédéral du gouvernement de Sao Paulo en 1917. Les bénéfices résultant de la valorisation devaient être divisés à parts égales.

Un peu plus tard une entente fut conclue entre le gouvernement fédéral et les gouvernements d'Etats, par laquelle les Etats s'engagèrent à percevoir une taxe équivalant à environ $2.43 par sac et à déposer quotidiennement leurs perceptions au compte du Conseil national du café; cet argent devait être employé exclusivement à l'achat, pour l'élimination, de l'excès de production et des stocks actuels pour équilibrer l'offre et la demande. La destruction des stocks de surplus par le feu fut entreprise en juin 1931, elle fut continuée à raison d'un million de sacs par mois. Outre ces mesures, le gouvernement fédéral promulgua, en décembre 1931, un décret élevant la surtaxe d'exportation à l'équivalent de $3.65 (monnaie des E.-U.) par sac, et la taxe de 3s. de Sao Paulo fut abolie. Le Conseil national du café fut autorisé à entrer dans le commerce, et des fonds furent pourvus par la Banque du Brésil. En mai 1932, la taxe d'exportation fut haussée jusqu'à l'équivalent de $4.20 par sac, mais elle fut plus tard réduite à $3.74 par sac. Plus tard en 1932, un décret fut promulgué interdisant toute nouvelle plantation de caféiers pendant trois ans et un contingent d'exportation fut établi.

En février 1933 le gouvernement fédéral assuma le contrôle complet de la défense du café; un Service national du café fut établi sous le Ministère des finances: son programme paraissait comporter l'achat et l'entreposage de l'équivalent de la récolte d'une année, la destruction par le feu à raison de 750,000 sacs par mois et la restriction des exportations par l'application d'une taxe d'exportation de 50 pour cent ad valorem. On fit également des tentatives au moyen d'accords commerciaux pour obtenir de meilleurs débouchés pour le café de surplus.[9]

Le système de valorisation du café comprend donc plusieurs facteurs parmi lesquels les suivants sont à noter: (1) surtaxe d'exportation; (2) restriction des entrées du café aux ports d'exportation; (3) établissement d'une taxe sur les nouvelles plantations autres que les remplacements; (4) achats pour prévenir l'encombrement des marchés; (5) destruction des stocks de surplus; (6) dépendance dans une grande mesure sur le crédit étranger.

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[9] Lynsky, Meyer. Agricultural Price Supporting Measures. Bulletin de la Pan American Union, juillet 1933. p. 569, 572-73.

# ANALYSE COMMERCIALE DES OPERATIONS COMBINEES DE VINGT-CINQ COMPAGNIES LAITIERES COOPERATIVES AU CANADA[1]

A. E. Richards[2]

De tous les établissements laitiers coopératifs inscrits sur les registres de la Division de l'économie, le plus ancien assurément est la "Stanley Bridge Dairying Company", de Stanley Bridge, I.P.-E., établie en l'année 1885, et qui fonctionne toujours. Depuis quarante-huit ans, cette compagnie fabrique du beurre et du fromage et conduit son industrie sur une base coopérative. Cinq ans plus tard, dans cette même province, la fromagerie de Hamilton, affiliée à la Kensington Dairying Association, ouvrit ses portes et vers 1900, il y avait sur l'Ile onze fabriques coopératives desservant leurs patrons. Il est à regretter que le nom du promoteur de ce premier développement de la coopération dans l'Ile du Prince-Edouard ne soit pas

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[1] Cet article a trait à une partie d'un rapport actuellement en cours de préparation à la Division de l'économie agricole, traitant de l'organisation commerciale des cultivateurs au Canada.

[2] Economiste agricole, Division de l'économie agricole, Ministère de l'agriculture, Ottawa.

TABLEAU 1 —BILAN COMBINE DE VINGT-CINQ COMPAGNIES COOPERATIVES LAITIERES AU 31 DECEMBRE 1931

| ACTIF: | $ | % |
|---|---|---|
| Actif courant: | | |
| Argent en caisse et en banque | 70,095 | 2 5 |
| Comptes et billets encaissables ... | 655,791 | 23 1 |
| Inventaire (marchandises) . | 323,896 | 11 4 |
| Divers . | 569,745 | 20 0 |
| Actif courant total | 1,619,527 | 57 0 |
| Actif fixe: | | |
| Etablissement, moins dépréciation . | 1,163,948 | 41 0 |
| Divers | 55,929 | 2 0 |
| Actif fixe total | 1,219,877 | 43 0 |
| Actif total | 2,839,404 | 100 0 |
| PASSIF ET VALEUR NETTE | | |
| Comptes payables | 256,331 | 9 0 |
| Emprunts de banque | 30,459 | 1 1 |
| Déboursés | 20,369 | 0 7 |
| Divers | 603,474 | 21 3 |
| Passif courant total | 910,633 | 32 1 |
| Hypothèques | 89,090 | 3 1 |
| Divers | 164,335 | 5 8 |
| Passif fixe total | 253,425 | 8 9 |
| Valeur nette: | | |
| Capital-actions | 1,098,074 | 38 7 |
| Reserve générale | 22,755 | 0 8 |
| Réserve pour imprevus | 116,066 | 4 1 |
| Divers | 328,853 | 11 6 |
| Surplus | 109,598 | 3 8 |
| Valeur nette totale | 1,675,346 | 59 0 |
| Passif total et valeur nette | 2,839,404 | 100.0 |

connu. A la même époque, ou peu après, des laiteries coopératives furent établies dans d'autres provinces et aujourd'hui ces établissements rendent un service utile à leurs patrons d'un bout à l'autre du Canada.

En 1932, 113 coopératives ont rempli le questionnaire qui leur avait été soumis sur le recensement économique des affaires des organisations commerciales agricoles au Canada. Ces compagnies ont un actif total de $3,898,060 et comptent, à titre de membres, 27,524 actionnaires producteurs. Le chiffre total d'affaires pour l'année finissant le 31 décembre 1931 se montait à $15,444,833.

Les rapports des différentes compagnies sont classés, compilés et analysés; les états de comptes sont réduits en pourcentages, qui permettent de faire des comparaisons entre les compagnies d'un même type. On applique alors certaines épreuves de proportions relatives on "relations" pour déterminer le rendement et la solidité de l'entreprise.

Les Tableaux 1 et 2 donnent les rapports combinés de vingt-cinq coopératives laitières, choisies dans six provinces canadiennes. Le bilan et les pourcentages de fonctionnement ont été calculés pour chaque compagnie et sont mis à la disposition des différentes compagnies qui peuvent ainsi les comparer avec la moyenne ou avec ceux d'autres coopératives. Une analyse de ce genre révèle de grandes variations et met en lumière certains points faibles dans la structure financière et la direction. Chacune des vingt-cinq compagnies est sous une direction et un contrôle séparés. Elles sont combinées dans cette présentation en une même organisation afin de donner une image fidèle de l'état financier de l'industrie laitière coopérative au Canada. En somme, comme le font ressortir ces tableaux, les coopératives laitières canadiennes paraissent être dans une situation raisonnablement saine et résistent d'une façon encourageante à l'épreuve économique actuelle.

Il est à noter cependant que cette analyse ne couvre qu'une année et ne saurait donc être concluante. Comme les bilans changent sans cesse et que chaque jour nouveau apporte un nouvel alignement dans la position relative des comptes, il serait nécessaire d'avoir des bilans couvrant un certain nombre d'années pour faire une appréciation raisonnable de l'industrie et voir si réellement elle fait des progrès ou si elle rétrograde. La valeur des statistiques que les organisations de cultivateurs fournissent à la Division de l'économie s'accroîtra donc avec les années. Il serait impossible, sans ces renseignements, de tirer des conclusions satisfaisantes ou de déterminer des proportions relatives régulières. Il faut espérer cependant que l'analyse sera utile aux différentes compagnies qui peuvent employer les "relations" comme base de comparaison pour déterminer leur statut relativement à la moyenne générale.

*Le bilan.*—L'examen du bilan (Tableau 1) montre que l'actif courant est de $1,619,527 et le passif courant de $910,633, soit une proportion de 1.78 à 1; c'est ce que l'on appelle la "relation courante". En d'autres termes, l'organisation, considérée comme un tout, avait $1.78 d'actif facilement convertible, couvrant chaque dollar de dette courante. Une relation de 2 à 1 est généralement considérée comme une base avantageuse pour plusieurs sortes de commerces. Parmi les vingt-cinq compagnies de ce groupe, il y en avait avec des relations courantes s'élevant jusqu'à 8 à 1 tandis que d'autres étaient en assez mauvais état, n'accusant seulement que 45 cents d'actif liquide pour chaque dollar de dettes courantes.

Les comptes et les billets encaissables forment un total assez considérable, se montant à $665,791 soit 23.1 pour cent de l'actif total. Certaines compagnies ont des créances qui se montent jusqu'à 50 pour cent de leur actif total, ce qui indique qu'elles font beaucoup de crédit. L'inventaire des marchandises se compose principalement de produits en magasin, de beurre, de fromage et d'autres produits laitiers. Exprimé en pourcentage des ventes totales, ceci ne se monte qu'à 4.9 pour cent. La valeur combinée de l'installation et de l'outillage, y compris les immeubles, se monte à $1,163,948, moins la dépréciation, soit 41.0 pour cent de l'actif total.

La dette courante, qui est de $910,633, est assez bien couverte par un actif immédiatement convertible de $1,619,527. La dette à long terme et les hypothèques qui se montent à $253,425 sont un poids qui pèse lourdement sur l'industrie, à moins qu'on ne prenne les moyens de les réduire systématiquement. La moyenne de 8.9 pour cent n'est pas grave, mais elle atteint jusqu'à 50 pour cent du passif total et de la valeur nette pour certaines compagnies.

Le capital-actions versé, qui forme un total de $1,098,074, représente un placement direct de 15,538 actionnaires dans le commerce ou un placement moyen de $71.59. Les privilèges d'actionnaires dans la plupart des compagnies sont limités aux patrons. Pour la majorité des compagnies laitières, la valeur au pair des actions est de $10. ou de $25.

*Valeur nette et dette.*—La valeur nette totale, qui représente le capital fourni par les membres à l'industrie est de $1,675,346, soit 59 pour cent du passif total et de la valeur nette. C'est là une situation satisfaisante quoique certaines compagnies tombent jusqu'à 20 pour cent. Pour d'autres, le pourcentage dépasse 80 pour cent. La relation de la valeur à la dette, consignée au tableau 3, est significative; on considère qu'elle est tout aussi importante que la relation courante dans une analyse commerciale. Dans cette industrie, elle est de 1.44 à 1, ce qui signifie que l'industrie appartient aux intéressés et que les intérêts des membres dépassent ceux des étrangers par près de 50 pour cent. Certaines compagnies se trouvent dans une situation encore plus favorable sous ce rapport, mais d'autres sont moins solides car leur dette dépasse leur valeur.

*Affaires et valeur de l'établissement.*—La relation entre les affaires et la valeur de l'établissement indique le rendement. Prenons encore une fois les opérations combinées comme celles d'une grande compagnie, et nous voyons par la relation que la compagnie a fait $5.83 d'affaires pour chaque dollar en établissement et en outillage. Trois établissements dans cette enquête ont fait plus de $10 d'affaires pour chaque $1 de valeur d'établissement tandis que six compagnies n'ont pas fait $2 d'affaires par $1 de valeur d'établissement. Cette faible relation de 2 à 1 indique un faible chiffre d'affaires par rapport à la capacité de l'installation. C'est peut-être à cause d'un manque de patronage ou d'une production décroissante mais trop souvent il faut en chercher la raison dans une trop grande expansion de l'établissement et de l'outillage par rapport à la quantité de gras de beurre. Dans certains cas, les membres ont acheté un équipement trop coûteux et trop élaboré.

La valeur nette peut être accompagnée d'un placement raisonnable en actif fixe. Si l'actif fixe dépasse la valeur nette d'une façon exagérée, la relation est hors de proportion, et l'on dit alors que la compagnie a fait un trop gros placement dans l'établissement. La relation "valeur nette à actif fixe" pour ce groupe composé est de 1.37 à 1 mais dans six établissements l'actif fixe est bien supérieur à la valeur nette et la relation est d'environ 0.5 à 1. Le capital d'exploitation est l'excès de l'actif courant sur le passif courant. Le capital net d'exploitation pour le groupe se monte à $708,894 soit 24.97 pour cent de l'actif total.

*Rapport d'opération.*—Le rapport des opérations montre que le commerce total des vingt-cinq compagnies groupées ensemble se montait à $6,786,598; ce total se compose de ventes de produits laitiers de ferme, au montant de $6,573,128 soit 96.86

TABLEAU 2 -ETATS DE COMPTES COMBINES DE VINGT-CINQ COMPAGNIES COOPERATIVES LAITIERES POUR L ANNEE FINISSANT LE 31 DECEMBRE 1931

| | $ | % du chiffre d affaires total | % de la marge brute totale |
|---|---|---|---|
| Chiffre d'affaires total | 6,786,598 | 100 00 | |
| Ventes de produits de ferme | 6,573,128 | 96 86 | |
| Payé aux producteurs | 4,440,290 | 65 43 | |
| Marge brute | 2,132,838 | 31 43 | |
| Ventes de marchandises | 149,512 | 2 20 | |
| Coût des marchandises | 138,660 | 2 04 | |
| Marge brute | 10,852 | 0 16 | |
| Autres recettes | 63,958 | 0 94 | |
| Marge brute totale | 2,207,648 | 32 53 | 100 00 |
| DEPENSES. | | | |
| Gages et salaires | 503,025 | 7 41 | 22 79 |
| Loyer | 11,522 | 0 17 | 0 52 |
| Dépréciation | 95,475 | 1 41 | 4 32 |
| Fournitures | 18,362 | 0 27 | 0 83 |
| Assurance | 10,935 | 0 16 | 0 50 |
| Taxes | 2,880 | 0 05 | 0 13 |
| Réclame | 3,536 | 0 05 | 0 16 |
| Intérêt sur les emprunts | 5,573 | 0 08 | 0 25 |
| Entretien des établissements | 982,835 | 14 48 | 44 52 |
| Divers | 314,208 | 4 63 | 14 23 |
| Dépenses totales | 1,948,351 | 28 71 | 88 25 |
| Revenu net de l'exploitation | 259,297 | 3 82 | 11 75 |
| Autre revenu | 3,799 | 0 06 | 0 17 |
| Revenu net pour la distribution | 263,096 | 3 88 | 11 92 |
| Disposition du surplus | | | |
| Dividendes | 71,999 | 1 06 | 3 26 |
| Remboursements aux patrons | 37,467 | 0 55 | 1 70 |
| Porté à la réserve | 95,681 | 1 41 | 4 33 |
| Total | 205,147 | 3 02 | 9 29 |
| Revenu non divisé | 57,949 | 0 86 | 2 63 |

pour cent du commerce total. Les ventes de marchandises par ces compagnies, c'est-à-dire d'aliments à bétail, d'engrais chimiques, d'instruments aratoires, etc., ne se monte qu'à $149,512 soit 2.20 pour cent du total. Les autres recettes, au total de $63,958, se composent du revenu de l'entrepôt, des crédits, etc., et ne représentent que 0.94 pour cent du total.

Sur cette somme de $6,573,128 que les compagnies ont tiré de la vente du lait, du beurre et du fromage, les patrons producteurs ont reçu $4,440,290 ou 68 cents sur chaque dollar des ventes. Des marchandises coûtant $138,660 ont été vendues aux patrons pour $149,512 à une marge de profit de 7.8 pour cent. Au total, les compagnies avaient une marge de plus de deux millions ou 32.53 pour cent du chiffre total d'affaires pour payer les frais d'opération. Cette marge variait d'une compagnie à l'autre depuis 40 pour cent jusqu'à 15 pour cent.

Les gages et les salaires sont l'un des plus gros déboursés; ils se montent à 22.79 pour cent des frais totaux. Les taxes et l'assurance combinées prennent moins de un pour cent et les frais de réclame moins de un quart de un pour cent. L'entretien de l'installation représente un montant considérable. Le total des dépenses a été de 88.25 pour cent de la marge brute, laissant une balance de 11.75 pour cent, laquelle, jointe à un autre revenu de 0.17 pour cent tiré de placements, etc., donne 11.92 pour cent soit près d'un huitième de la marge brute qui doit revenir aux producteurs comme remboursement ou comme versement à titre de dividende sur les actions.

TABLEAU 3.--ESSAIS DE “PROPORTIONS RELATIVES” APPLIQUEES AUX OPERATIONS COMBINEES DE VINGT-CINQ COMPAGNIES LAITIERES AU CANADA POUR L'ANNEE 1931

| | | |
|---|---|---|
| Actif courant au passif courant | | 1 78 à 1. |
| Valeur à la dette | | 1 44 à 1. |
| Chiffre d'affaires à la valeur de l'établissement | | 5 83 à 1. |
| Valeur nette à l'actif fixe | | 1 37 à 1. |
| Proportion pour cent d'argent à l'actif total | p.c. | 24 97 |
| Proportion pour cent des dépenses au chiffre d'affaires | p.c. | 28 71 |
| Affaires par employé | $ | 15,968 |
| Affaires par patron | $ | 363 |

Toutes ces compagnies suivent le principe coopératif de la distribution des surplus. Dans la plupart des provinces, les lois de l'incorporation règlent la distribution du surplus. Généralement, on ne met pas plus de 10 pour cent du surplus net en réserve jusqu'à ce qu'un montant se soit accumulé, égalant au moins 35 pour cent du capital-actions payé. L'intérêt accordé sur les actions entièrement payées varie de 6 à 8 pour cent. Le reste du surplus est alors divisé entre les patrons et les actionnaires, proportionnellement au chiffre des affaires qu'ils ont faites avec la société.

*Distribution du revenu net.*—Sur un revenu net, pour distribution, de $263,096, la somme mise en réserve par ces compagnies était de $95,681 soit 36.4 pour cent. L'intérêt sur les actions payées détenues par les actionnaires se montait à $71,999, équivalant à un dividende de 6.5 pour cent. La somme de $37,467 a été remboursée aux patrons qui ont contribué à l'industrie et le reste, $57,949, a été laissé au compte du revenu non divisé.

Ces compagnies laitières ont employé au total 425 personnes, y compris la direction et les ouvriers. Les salaires et les gages représentent, pour chaque employé, une moyenne de $1,183.59 pour l'année. Un facteur intéressant dans cette analyse est le montant d'affaires par employé qui, pour toutes les compagnies, atteint une moyenne de $15,963. Chez certaines compagnies, ce montant dépasse $20,000; dans d'autres, il tombe à $3,000. ce qui porte à croire que le travail n'était pas employé de façon à en obtenir le plein rendement.

Les patrons étaient au nombre de 18,675 et chacun d'eux a contribué en moyenne $363 d'affaires; ce chiffre varie depuis plus de $4,000 à moins de $100. Ces écarts dépendent surtout du degré de spécialisation en industrie laitière parmi les patrons de la beurrerie; pour bien des patrons, l'industrie laitière n'est qu'une industrie annexe de la ferme.

# LE COUT DE LA TRACTION MECANIQUE SUR LES FERMES DES PRAIRIES DANS L'OUEST DU CANADA[1]

E. G. Grest[2]

Une bonne partie de l'énergie motrice qui était autrefois fournie par les chevaux dans l'Ouest du Canada est maintenant fournie par des tracteurs de différentes marques et de différentes dimensions. Les chevaux sont toujours la source la plus importante d'énergie motrice et ils le resteront probablement bien des années, mais il y a une place pour les deux genres de traction sur la ferme. La grande difficulté est de bien régler les besoins de la traction à la dimension de la ferme. Il est essentiel pour cela de connaître le coût du tracteur, la dimension de la ferme et le nombre d'heures d'utilisation, etc.

La discussion suivante est basée sur l'analyse du fonctionnement de 256 tracteurs du type moderne qui sont employés pour presque tous les genres de travaux des champs et la transmission d'énergie par courroie sur les fermes de l'Ouest canadien. Ces tracteurs sont classés, pour fins de comparaison, suivant le nombre de charrues qu'ils traînaient sur les fermes visitées. Ceci donne quatre classifications—tracteur à deux charrues, tracteur à trois charrues, tracteur à quatre charrues et tracteur à cinq charrues.

Nous présentons au tableau 1 les détails du coût de fonctionnement par tracteur et par heure. Le combustible employé était en grande partie de la gazoline; il y avait aussi du pétrole et de petites quantités de distillé. Le prix moyen payé pour la gazoline, déduction faite du rabais sur la taxe, était de 27 cents le gallon.

Les frais en argent comptant du fonctionnement du tracteur variaient de 59 à 68 pour cent du coût total du fonctionnement; pour le tracteur à trois charrues, la dimension la plus appréciée, ce chiffre était de 59 pour cent. Les tracteurs à trois charrues ont fonctionné en moyenne 417 heures par année et se trouvaient sur les fermes dont l'étendue moyenne était de 583 acres. Les déboursés en argent comptant étaient de $336.50 par tracteur et par année, soit une moyenne de 81 cents l'heure. Le total des frais de fonctionnement, qui comprenaient l'intérêt, la dépréciation et l'entretien, se montait à $574.30 par année, soit $1.38 l'heure. Le coût moyen par heure pour les principaux comptes était le suivant: combustible 65c.; huile lubrifiante 11c; graisse 1c.; parties et main-d'oeuvre pour entretien 6c.; intérêt 12c.; dépréciation 38c. et valeur de l'entretien et de l'ajustage 7c. l'heure.

La quantité de combustible consommé par les tracteurs à trois charrues était de 2.41 gallons l'heure, celle d'huile lubrifiante était en moyenne d'un dixième de gallon par heure. Les chiffres pour les tracteurs des autres dimensions sont consignés au Tableau 1.

*Heures d'utilisation et coût par heure.*—Le coût par heure des travaux au tracteur est influencé principalement par le nombre d'heures de travail ainsi que le font voir les données présentées au tableau 2. Pour les tracteurs à trois charrues, lorsque le nombre d'heures de travail passait d'une moyenne de 117 par tracteur à 794, le coût par heure diminuait de $2.31 à $1.17. De même, une diminution dans le coût de $2.45 à $1.47 par heure a été notée pour les tracteurs à quatre charrues. Un montant considérable des frais fixes reste constant, quel que soit le nombre d'heures que le tracteur est employé. Ils forment donc une plus grande proportion du coût total lorsque les tracteurs sont employés pour un petit nombre d'heures. Pour cette raison, il est douteux qu'un tracteur soit jamais un sage placement sur une ferme de l'Ouest

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[1] Les données employées dans cet article ont été recueillies au cours de l'été de 1931 dans les districts de Olds, Bow Island, Foremost, Hilda et Irvine dans l'Alberta et dans les districts de Davidson, Craik, Maple Creek et Richmond dans la Saskatchewan. L'étude a été conduite coopérativement par le Comité canadien des problèmes du pionnier, le Service de l'exploitation des fermes de l'Université de la Saskatchewan, l'Université de l'Alberta et la Division de l'économie agricole du Ministère fédéral de l'Agriculture.

Etat préliminaire, sujet à être revisé et corrigé. Ce résumé a été préparé d'après le manuscrit original par L. V. Parker, Adjoint de campagne, Division de l'économie agricole, Ottawa.

[2] Autrefois adjoint de campagne, Division de l'économie agricole, maintenant inscrit à l'école des diplômés, Université du Minnesota, à titre de fellow de la Saskatchewan Research Foundation.

TABLEAU 1 FRAIS DE FONCTIONNEMENT DES TRACTEURS PAR TRACTEUR ET PAR HEURE SASKATCHEWAN ET ALBERTA

| Frais pour 1 année finissant le 1er avril 1931 | Tracteur | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | A 2 charrues | | A 3 charrues | | 4 charrues | | 5 charrues | |
| Nombre de tracteurs | 23 | | 149 | | 77 | | 7 | |
| Nombre moyen d'heures au travail 1930 | 246 | | 417 | | 482 | | 386 | |
| Valeur moyenne | $373 | | $842 | | $984 | | $831 | |
| Dimension moyenne de la ferme, acres cultivés | 376 | | 583 | | 706 | | 771 | |
| | Par tracteur | Par heure | Par tracteur | Par heure | Par tracteur | Par heure | Par tracteur | Par heure |
| Gallons de combustible consommé | | 1.90 | | 2.41 | | 2.84 | | 3.21 |
| Coût du combustible | | $0.51 | | $0.65 | | $0.77 | | $0.89 |
| Gallons d'huile à cylindre | | 0.08 | | 0 10 | | 0.12 | | 0.21 |
| Coût de l'huile à cylindre | | $0 09 | | $0 11 | | $0 16 | | $0.24 |
| Coût de la graisse | | $0.01 | | $0 01 | | $0.01 | | $0.02 |
| Parties, plus main-d'oeuvre louée pour réparations[1] . | | $0 06 | | $0.04 | | $0.06 | | $0.22 |
| | $ | $ | $ | $ | $ | $ | $ | $ |
| Total des déboursés comptants | 166 0 | 0.67 | 336.5 | 0.81 | 479.6 | 0.99 | 529.4 | 1.37 |
| Intérêt à 6% | 22.4 | 0 09 | 50.5 | 0 12 | 59.1 | 0.12 | 49.9 | 0.13 |
| Dépréciation | 78 0 | 0 32 | 132 7 | 0 38 | 190.9 | 0.40 | 163 7 | 0 42 |
| Valeur de l'entretien et, ajustage | 11 5 | 0 05 | 27.6 | 0 07 | 32.5 | 0.07 | 37 0 | 0 10 |
| Heures d'entretien et d'ajustage | 33.9 | 0.14 | 67 7 | 0.16 | 78.2 | 0.16 | 65 6 | 0.17 |
| Total des frais de fonctionnement | $277.9 | $1.13 | $574.3 | $1.38 | $762 1 | $1.58 | $780 0 | $2.02 |
| Pourcentage des déboursés comptants relativement au total | | 59 | | 59 | | 62 | | 68 |

[1] La main-d'oeuvre louée pour les réparations équivaut à ½c par heure pour les tracteurs à deux, trois, et quatre charrues et à quatre cents par heure pour les tracteurs à cinq charrues

TABLEAU 2 —HEURES DE TRACTION PAR AN EN RELATION AU COUT TOTAL DES TRACTEURS EN FONCTIONNEMENT PAR HEURE

| Heures de traction par an | Tracteur | | | | | |
|---|---|---|---|---|---|---|
| | A trois charrues | | | A quatre charrues | | |
| | Nombre | Moyenne heures de traction | Coût de l énergie par heure | Nombre | Moyenne heures de traction | Coût de l'énergie par heure |
| 1 - 199 | 34 | 117 | $2 31 | 8 | 148 | $2 45 |
| 200 - 399 | 47 | 305 | 1 59 | 25 | 324 | 1 76 |
| 400 - 599 | 33 | 484 | 1 30 | 24 | 507 | 1 52 |
| 600 et plus | 35 | 794 | 1 17 | 20 | 781 | 1 47 |
| Tous tracteurs | 149 | 417 | 1 38 | 77 | 482 | 1 58 |

du Canada, à moins qu'il n'y ait, sur la ferme, de quoi l'employer 500 heures au moins à un travail utile.

*Dimension de la ferme et heures d'emploi du tracteur.*—La question de savoir de quelle grandeur une ferme devrait être pour fournir 500 heures de travail utile pendant l'année dépend de la proportion de travaux de culture exécutés par un tracteur et aussi de l'intensité de l'exploitation. Si l'on suppose que les tracteurs font tous les travaux des champs, on trouve que la dimension de la ferme nécessaire pour permettre un emploi économique du tracteur est la suivante:— tracteur à deux charrues—une moitié à trois quarts de section en supposant que chaque quart de section couvre de 140 à 150 acres de terre en culture; tracteur à trois charrues—trois quarts à une section et un quart; tracteurs à quatre charrues, une à une section et demie. Si l'on se sert de chevaux en même temps que de tracteurs, alors il faut compter dans la superficie qui précède de 30 à 50 acres de terre en culture par cheval.

TABLEAU 3.—COUT DES DIFFERENTES OPERATIONS DE CULTURE AU MOYEN D'UN TRACTEUR A 3 CHARRUES

| | Labour de printemps et d'automne | Binage | Semailles | Disquage double | Hersage | Coupe |
|---|---|---|---|---|---|---|
| Nombre de machines. . . | 86 | 25 | 32 | 93 | 15 | 21 |
| Dimension ordinaire des machines .. | 3-14"G | 12' | 14' | 10'T | 32' | 10' |
| Acres par heure de machine. .. | 1.24 | 3.66 | 4.22 | 3.21 | 9.90 | 3.01 |
| | $ | $ | $ | $ | $ | $ |
| Coût moyen par acre 1930: | | | | | | |
| Coût de la traction . . . | 1.12 | 0.38 | 0.33 | 0.43 | 0.14 | 0.46 |
| Coût de la main-d'oeuvre . | 0.33 | 0.11 | 0.09 | 0.13 | 0.04 | 0.22 |
| Coût total... . . . | 1.45 | 0.49 | 0.42 | 0.56 | 0.18 | 0.68 |
| | $ | $ | $ | $ | $ | $ |
| Coût moyen évalué par acre 1932: | | | | | | |
| Coût de la traction ... ... | 1.12 | 0.38 | 0.33 | 0.43 | 0.14 | 0.46 |
| Coût de la main-d'oeuvre .. | 0.22 | 0.07 | 0.06 | 0.09 | 0.03 | 0.14 |
| Coût total.. .. . | 1.34 | 0.45 | 0.39 | 0.52 | 0.17 | 0.60 |

*Coût des travaux par acre.*—Le coût de l'exécution de quelques-uns des principaux travaux des champs avec un tracteur à trois charrues est présenté au tableau 3. Voici quels ont été les frais par acre en 1930: labours $1.45, scarifiages 49 cents, semailles 42 cents, disquage double 56 cents, hersage 18 cents et coupe 68 cents. En 1932 il y a eu une réduction d'environ 33 pour cent dans les frais de main-d'oeuvre mais les frais de fonctionnement sont restés les mêmes qu'en 1930. Le tracteur à trois charrues était le genre de machine le plus employé, et il a exécuté en moyenne les travaux des champs aussi économiquement que le tracteur à quatre charrues et à meilleur compte que le tracteur à deux charrues. En théorie, le tracteur à quatre charrues devrait faire les travaux plus économiquement parce qu'il économise sur les frais de main-d'oeuvre par acre, mais dans bien des cas la traction s'exerçait sur des instruments de dimension recommandée pour des tracteurs à trois charrues. Les tracteurs de toutes les dimensions n'étaient généralement pas assez chargés et il en résultait un emploi peu économique de la force motrice.

*Comparaison avec le coût de l'énergie chevaline.*—On a constaté en 1930 que les frais d'exécution des principaux travaux de culture étaient moins élevés avec les tracteurs qu'avec les chevaux, mais en 1932, il y avait eu une telle diminution dans les prix des aliments et de la main-d'oeuvre tandis que les frais des tracteurs restaient à peu près les mêmes, que l'énergie chevaline était beaucoup plus économique que celle des tracteurs. En règle générale le coût total de l'exécution des travaux de la ferme avec les chevaux est moins élevé qu'avec les tracteurs lorsqu'il faut plus de deux boisseaux d'avoine pour acheter assez de combustible pour faire fonctionner un tracteur à trois charrues pendant une heure.

## OUVRAGES ECONOMIQUES

RUSSEL, SIR E. JOHN. THE FARM AND THE NATION. George Allen and Urwin Limited, Publishers, Museum Street, Londres, 1933, p. 240.

L'auteur de ce livre, Sir E. John Russell, est directeur de la Station Agronomique de Rothamstead. Cet ouvrage offre un intérêt direct pour les gens au Canada ainsi qu'en Grande-Bretagne qui s'intéressent aux problèmes agricoles et aux initiatives tentées pour les résoudre.

Le premier chapitre du livre est intitulé "Les vivres de la nation, d'où viennent-ils?" Nous y trouvons cette question "Est-ce là le meilleur moyen d'utiliser notre richesse nationale, ou ne ferions-nous pas mieux de produire plus de ces vivres nous-mêmes?" Les chapitres suivants répondent à la question.

Le chapitre II donne un résumé des "Hauts et des bas de l'agriculture britannique". L'auteur présente une revue historique de la tendance agricole britannique depuis les premiers temps jusqu'à nos jours. Dans le chapitre III "Notre terre arable, comment nous l'employons", l'auteur donne une description intéressante des régions agricoles de la Grande-Bretagne, des types de sols, de la topographie, des changements historiques et de l'utilisation actuelle de la terre.

"Le résultat de nos efforts agricoles" forme la base de la discussion dans le chapitre IV. Les trente millions d'acres de terre cultivée en Grande-Bretagne, joints aux fourrages importés, produisent quarante pour cent des vivres nécessaires pour quarante-cinq millions d'hommes (1⅓ acre, plus les fourrages importés, nourrissent une personne).

Les chapitres V et VI traitent de l'Empire comme source de vivres, et de la possibilité d'augmenter la part de l'Empire dans le total des importations. Sur les 60 pour cent des vivres importés, l'Empire fournit 21 pour cent et les pays étrangers 39 pour cent. Résumant les constations des chapitres V et VI l'auteur dit, "Nous pourrions, sans difficulté, nous ravitailler entièrement dans les pays britanniques pour le lait, les pommes de terre, le mouton, l'agneau et le fromage . . . . Pour le pain et les fruits, nous nous suffirions presque à nous-mêmes, mais peut-être pas tout à fait . . . . pour le boeuf, le bacon, le beurre et les oeufs, il serait difficile, mais non pas impossible de se suffire." Mais la question se pose "Devrions-nous prendre les mesures nécessaires pour leur (les pays étrangers) fermer nos marchés?"

Quelques-unes des difficultés du cultivateur sont présentées au chapitre VII. En agriculture, la production est lente et ne peut être hâtée; c'est pourquoi il est difficile de la régler suivant les changements de prix. Les cultivateurs souffrent d'une baisse de prix parce qu'ils ne peuvent modifier leurs opérations assez vite. On ne peut pas non plus faire face à une baisse de prix en réduisant les salaires, car la loi du salaire minimum s'y oppose.

Le chapitre VIII discute les moyens d'utiliser les terres arables de la Grande-Bretagne. Enfin, dans le chapitre IX l'auteur traite de la question du remplacement des hommes par les machines en agriculture.

L'auteur conclut en disant qu'il y aurait trois moyens de traiter l'agriculture britannique: " (1) l'organiser pour la production de la plus grande quantité de nourriture possible, tirée de notre propre sol; (2) l'organiser pour fournir du travail aux hommes supplantés par les méthodes modernes et par les machines; (3) la laisser lutter du mieux qu'elle le peut contre les importations non restreintes de vivres venant d'outre-mer, le cultivateur étant entièrement libre de gagner le bénéfice qui peut revenir à ceux qui travaillent sur la terre, quelle que soit la somme totale de richesse produite."

"Ces trois propositions, entièrement distinctes, sont en somme incompatibles . . . . La production d'une quantité maximum de vivres nous oblige à protéger le cultivateur contre les risques de baisses de prix pendant la période de développement." Ceci comporte un système de contrat, avec prix convenus, ou un système de contingentement. "Le résultat des importations sans restriction d'outre-mer est d'obliger les cultivateurs à réduire les frais de production, et ils le font en réduisant la main d'oeuvre. Jusqu'à ces tout derniers temps, les hommes ainsi supplantés émigraient ou trouvaient du travail dans les villes. En regard de l'économie dans le cas de la nourriture de ces hommes remplacés, il faut mettre le coût de leur entretien, dans l'oisiveté ou dans des travaux non productifs."

"Il est possible au moyen de petites propriétés et des fermes de familles de trouver du travail pour quelques-uns de ces hommes qui sont sortis de l'agriculture et de l'industrie. On équilibrerait ainsi tant soit peu l'exode des cultivateurs causée par l'extension des propriétés et le machinisme. Mais ces petites fermes sont coûteuses à établir, difficiles à exploiter et elles exigent de plus longues heures et un travail plus dur pour l'opérateur et sa famille. Il y aurait moyen d'établir sur les terres des groupements qui se suffiraient à eux-mêmes et qu'on munirait de machines modernes pour leur éviter ces difficultés . . . ."

"Le choix entre ces différentes alternatives devrait être fait rapidement et de façon définitive. Le problème ne fera qu'empirer avec le temps."

## NOTES

Un bulletin du Service du recensement, du Bureau fédéral de la Statistique, basé sur le recensement de 1931 montre que les nombres d'ouvriers et d'ouvrières agricoles à gages en 1931 étaient respectivement de 197,204 et de 1,800. Les salaires moyens de ceux qui ont fait rapport étaient de $319 par an pour les hommes et de $275 pour les femmes. Les hommes ont été employés en moyenne 43.56 semaines par année, les femmes 43.83 semaines. La moyenne des salaires pour les hommes employés dans toutes les industries était de $927 par an, pour les femmes, de $560. Les hommes étaient en moyenne employés 41.12 semaines et les femmes 46.59 semaines en 1931.

* * *

A une réunion récente tenue à Regina, il a été décidé de faire envoyer par les municipalités et les comités locaux des pools du blé et du bétail, des questionnaires pour se renseigner sur les quantités de fourrages qui seront nécessaires dans les régions affectées par la sécheresse avant que l'on prenne des mesures pour fournir des fourrages supplémentaires. Des représentants des pools du blé et du bétail, de l'Association des municipalités rurales de la Saskatchewan, de la Commission du Secours, et du Ministère provincial de l'Agriculture à Regina, assistaient à cette réunion. On a discuté également le rapport de ce qui a déjà été fait pour fournir des fourrages aux régions affectées.

* * *

Les officiers de la Société canadienne de l'économie agricole pour 1933-34 sont les suivants: Président—Dr. W. V. Longley, Collège d'agriculture, Truro, Nouvelle-Ecosse; Vice-Président, H. C. Bois, Division de l'économie rurale, Ministère de l'Agriculture, Québec, P.Q.; Secrétaire, J. Coke, Division de l'économie, Ministère de l'Agriculture, Ottawa; Comité exécutif: Dr. T. W. Grindley, Bureau fédéral de la Statistique, Ottawa, Dr. W. Allen, Université de la Saskatchewan, Saskatoon, H. R. Hare, Association des producteurs de lait des terres basses de l'intérieur, Vancouver, F. W. Reinoehl, Colonization Finance Corporation, Winnipeg.

* * *

Dans un article paru dans "The Lighter", du 16 septembre, au sujet du tabac canadien au Royaume-Uni, M. T. J. Major, Service du tabac, Ferme expérimentale centrale, Ottawa, dit ce qui suit: "En somme, la situation est assez satisfaisante, mais il est important au plus haut point que l'on évite la surproduction. Ce n'est que par un développement lent, graduel, basé sur un produit de qualité toujours meilleure, que l'on parviendra à établir un débouché permanent pour le tabac canadien sur les marchés des vieux pays."

* * *

MM. A. Gosselin, Division de l'économie, Ministère de l'Agriculture, Ottawa, et R. Lécuyer, Division de l'économie rurale, Ministère de l'Agriculture, Québec, ont terminé les travaux de campagne dans une étude sur le prix de revient des pommes dans le Québec. Ils se sont procuré également des renseignements sur le coût du développement d'un verger jusqu'à l'âge de rapport.

* * *

Les quantités de blé consignées pour l'exportation pendant la semaine finissant le 29 septembre, ont été moins considérables que la semaine précédente et d'environ 3,000,000 de boisseaux inférieures à celles de la même semaine l'année dernière. Il y avait en entrepôt, au 29 septembre, 226,218,782 de boisseaux de blé canadien tandis que la quantité entreposée pendant la même semaine en 1932 était de 198,239,902 boisseaux.

* * *

La Commission de stabilisation de l'Okanagan a été formée pour diriger la vente des fruits en Colombie-Britannique pendant la saison de 1933-34. Le Major M. V. MacGuire, qui était gérant du Comité du Cartel qui a fonctionné l'année dernière, est gérant pour le nouveau comité.

* * *

Andrew Fulton, Représentant commercial de l'Association des producteurs de fruits de l'Ontario, fait rapport que les poires Bartlett de l'Ontario se vendent aisément sur les marchés anglais. Les mannes de 2-2¼ ont fait 12/- à 14/6 et quelques demi-barils, contenant 96 livres de fruits, ont obtenu 20/-.

* * *

The Ontario Milk Producer, septembre, 1933, signale les prix suivants obtenus pour le lait dans les villes d'Ontario: St. Catharines et Niagara Falls $1.81 le qtl.; Toronto, Hamilton et Oshawa $1.81; Kitchener $1.40; London $1.00 (a monté depuis à $1.40); St. Thomas $1.55; Sarnia $1.30; Windsor $1.40.

* * *

Le premier paiement pour le blé vendu en commun sera de 45c. le boisseau à Fort William, d'après un rapport que vient de publier la Direction du pool du blé de la Saskatchewan.

* * *

La Coopérative des ventes du bétail de l'Ile du Prince-Edouard a été organisée le 1er août. Une constitution a été adoptée par le Bureau des Directeurs. La nouvelle organisation recevra les expéditions de 28 clubs sur l'Ile.

* * *

Une corporation a été organisée sous l'administration du règlement agricole pour acheter le surplus des produits de la ferme et les distribuer à 3,500,000 familles qui sont actuellement sur les listes du secours aux Etats-Unis. On dit que les fonds pour ces achats seront pourvus par les taxes de fabrication, les subsides accordés sous la Loi fédérale d'urgence de 1933 et la Corporation de reconstitution.

# NOTES ET NOUVELLES

## UNE SECTION ECONOMIQUE TRIMESTRIELLE DANS LA REVUE AGRONOMIQUE

A commencer avec le présent numéro, *l'Economiste Agricole*, revue s'occupant du côté commercial de l'agriculture publiée par la Division d'Economie Agricole du Ministère fédéral de l'Agriculture, paraîtra chaque trimestre comme une section de la *Revue Agronomique*. Cette publication trimestrielle sera faite en français aussi bien qu'en anglais. Des compressions budgétaires, en supprimant les fonds reservés à la publication de *l'Economiste Agricole* par la Division d'Economie Agricole, empêchèrent sa publication pendant les mois d'été et les pages que l'on trouvera dans le présent numéro remplacent les numéros 7, 8 et 9, juillet à septembre. Des réponses extrêmement favorables à un questionnaire envoyé à tous ceux dont le nom figurait sur la liste d'envoi justifie l'effort fait par la Division d'Economie pour continuer la publication sous une forme ou sous une autre. Il faut espérer que les arrangements faits pour publier l'ancien *Economiste* comme une partie de la *Revue Agronomique* seront à l'avantage réciproque des deux publications.

Pour ceux qui ne sont pas familiers avec *l'Economiste Agricole* tel qu'il paraissait, il n'est pas inutile d'expliquer que cette revue consistait principalement en articles rapportant le travail de la Division d'Economie Agricole. Le présent numéro contient une étude de M. J. Coke sur le contrôle gouvernemental des marchés en prenant comme démonstration la valorisation du café au Brésil. M. A. E. Richards présente de la documentation sur les affaires des sociétés coopératives laitières et M. E. G. Grest donne un rapport sur le côut d'opération des tracteurs dans l'Ouest canadien. Des nouvelles d'actualités et des revues sur la littérature économique courante trouvent aussi une place régulière dans l'Economiste.

### ANALYSE ECONOMIQUE MENSUELLE

La section intitulée "La Situation Economique" présentera de l'interêt pour tous les techniciens agricoles. Cette section donne une interprétation prise au point de vue agricole des nombres-indices annuels et mensuels computés par le Bureau fédéral de Statistique en ce qui concerne les prix et la production. Le tableau contenu dans le présent numéro donne les moyennes annuelles de 1913 à 1932 et les moyennes mensuelles pour l'année en cours. Cette section de *l'Economiste* sera préparée mensuellement pour la *Revue Agronomique* par la Division d'Economie. Les membres de la C.S.T.A. trouveront donc dans leur revue une analyse mensuelle de la situation agricole et une section trimestrielle d'études sur des sujets économiques intéressants.

### EMPLOI DES NOMBRES-INDICES

Le progrès des sciences physiques et biologiques est dû pour une part considérable au développement des méthodes de mesure des divers phénomènes. La science économique a souffert de la difficulté qu'il y a à mesurer exactement les phénomènes hautement dynamiques dont elle essaie de formuler les lois. L'emploie général des nombres-indices des variations dans les prix et la production, en temps que système de mesure reconnu, date à peine du commencement du siècle présent, et leur emploi dans les journaux et les périodiques populaires est un développement d'après guerre. Il est cependant évident qu'ils sont destinés à devenir une part de nos conversations journalières dans un avenir rapproché. Il est possible que d'ici à quelques années ils forment la base d'évaluation de la valeur-or de la monnaie, remplaçant l'évaluation basée sur la valeur marchande de l'or lui-même. Un tel système est déjà en application en Suède et dans quelques autres pays d'Europe où les prix sont maintenus constants au niveau désiré.

Il nous sied donc de nous familiariser avec les nombres-indices. Warren et Pearson dans leur livre "Les Prix" définissent ainsi les nombres indices:

"Il est difficile de comparer directement les prix de commodités différentes. Si le blé vaut un dollar par boisseau et la café 10 cents par livre, on est obligé de comparer ces prix à des prix précédents avant de pouvoir juger lequel est relativement élevé ou relativement bas. Le prix du blé peut être comparé aux prix du blé pendant une période antérieure sur une base de pourcentage, et de même le prix du café peut être comparé a des prix antérieurs. Si le prix du blé est 90% du prix précédent et le prix du café 110 pour cent du prix précédent, ce chiffre de 90 peut être comparé au chiffre de 110. Ces deux chiffres représentent des nombres-indices des prix des deux produits.

"Si l'on obtient des nombres-indices pour plusieurs produits et qu'on en fasse la moyenne, il devient possible de juger le niveau général des prix. Par exemple le Bureau américain de Statistique publie un nombre-indice du prix de gros de 784 produits Les prix de gros en 1920 étaient plus du double de la moyenne de ceux des cinq années d'avant la guerre, mais en 1932 les prix étaient au-dessous du niveau d'avant guerre. D'ordinaire le meilleur moyen de juger le prix d'un produit particulier est de le comparer au niveau général des prix représenté par un nombre-indice tel que celui donné ci-dessus. Par exemple en juin 1932 le nombre-indice pour tous les produits était de 93%. Le nombre-indice du prix de blé sur la ferme était 41; celui du cotton 36. Comparés à d'autres choses, le blé et le coton étaient très bon marchés."

Maints lecteurs qui ont accepté l'idée que les nombres-indices représentent un système standard de mesure et d'observation des phénomènes économiques sont quelque peu troublés de voir les économistes changer l'année de base pour satisfaire ce qui semble être leur propre commodité. La tendance pour la plupart d'entre nous est d'utiliser les années ayant immédiatement précédé la guerre comme base à laquelle rapporter les problèmes d'ordre social ou économique. Nous aimons donc voir nos tableaux de nombres-indices prendre pour valeur 100 l'année 1913, ou la moyenne des cinq années 1910-1914. Nous considérons que cette période représentait "la normale" et nous nous demandons si nous avons jamais été normaux depuis.

Il y a cependant des difficultés à baser toutes les tables sur les années d'avant guerre. En 1929 le Bureau fédéral de Statistique à revisé tous ses indices en prenant 1926 comme année de base. Certains calculs remontant aussi loin que 1867, faits sur la base 1913, ont été refaits dans un but historique. Une des principales raisons pour prendre comme année de base une année d'après guerre est que le nombre des séries pour lesquels le Bureau obtient les prix de gros a augmenté de 236 en 1913 à 502 en 1926. La plus grande diversité des produits et le changement considerablé dans leur importance relative obtenus dans les séries de 1926, donnent une image beaucoup plus exacte de la situation des prix que des nombres-indices basés sur 236 commodités telles que produites en 1913.

Le niveau des prix pour l'année 1926 étant pratiquement équidistant des niveaux de 1925 et 1927 correspond environ à la moyenne de 1925, 1926 et 1927. Une autre raison pour adopter 1926 est que le Bureau américain de Statistique emploie cette même année pour ses indices des prix de gros de 784 commodités. Ccei facilite l'étude des mouvements des prix dans les deux pays.

## IMPORTANCE D'UNE DOCUMENTATION ECONOMIQUE EXACTE

Nous espèrons que l'inclusion régulière de *l'Economiste Agricole* dans la *Revue Agronomique* rencontrera l'approbation de nos membres et souscripteurs. Depuis longtemps ceux de nos membres engagés dans le vulgarisation ou dans des entreprises commerciales demandent des articles d'ordre plus pratique. En même temps, tous les membres étant d'accord pour que nous ne fassions pas de journalisme agricole au sens ordinaire du terme, il a été difficile de satisfaire la demande.

C'est notre impression que l'inclusion du matériel économique décrit ci-dessus intéressera tous les membres de la C.S.T.A. Nous sommes fiers de dire au Canada que nos hommes de recherche ne se sont pas éloignés des problèmes immédiats et fondamentaux des cultivateurs. En fait, il y a peu de nos savants qui ne soient en contact personnel avec des cultivateurs et des étudiants fils de cultivateurs. Il n'est pas suffisant que nos techniciens agricoles soient à même de répondre à des questions se rapportant à leurs diverses spécialités. Tous, sinon comme économistes, au moins comme citoyens éduqués et informés, nous avons à exprimer notre opinion sur les problèmes économiques courants et la façon dont ils affectent les cultivateurs. Ces questions nous sont posées par des cultivateurs au cours de conversations qui n'ont rien de formel, d'homme à homme, notre position officielle étant entièrement laissée de côté. C'est souvent le moment où des directives peuvent être données avec le plus de chances de succès. Pour qu'elles vaillent quelque chose, il faut cependant que ces directives soient basées sur quelque chose de plus substantiel que la lecture de la presse quotidienne. Les pages économiques de la *Revue Agronomique* fourniront à nos lecteurs une base d'information précise avec laquelle ils trouveront certainement avantage à se familiariser pour comprendre et juger les questions économiques qui s'imposeront chaque jour davantage à leur attention.

# RESUME DES ARTICLES PUBLIES EN ANGLAIS DANS CE NUMERO

## EFFET DE QUELQUES ENGRAIS CHIMIQUES SUR LA COMPOSITION BOTANIQUE ET LE RENDEMENT DES PRAIRIES PERMANENTES. F. S. Nowosad, Macdonald College, McGill University, P.Q.

Des prairies permanentes de la région de Cowansville, P.Q., ont été utilisées pour mesurer l'influence de l'azote, du phosphore et de la potasse, seuls ou en combinaison, avec ou sans chaux. Les expériences ont été conduites en 1931 et 1932. La chaux a donné un surplus de rendement important dans une série de parcelles et une diminution importante dans une autre série. Le phosphore, la potasse et l'azote ont augmenté le rendement partout où on les a appliqués. La première année, des accroissements importants ont été obtenus dans les parcelles recevant les traitements Ca N.P.K., N P K, Ca P K, P. K, et Ca P. La seconde année seule l'application complète Ca N P K a donné un accroissement important. Il semble que la seconde année les différences entre les diverses parcelles n'aient pas été aussi grandes que la première année.

Bien que l'influence des traitements sur la composition botanique ne soit pas encore absolument définie, il semble que les traitements aient une influence sur la proportion des diverses espèces. Lors de la première expérience la chaux a augmenté le pourcentage d'herbes utiles et diminué les mauvaises herbes, la mousse et l'espace dépourvu de végétation. Le superphosphate a augmenté le trèfle les deux années. Les autres éléments n'ont pas eu de résultats importants. Dans la seconde expérience, la chaux a augmenté le pourcentage d'herbes et réduit le pourcentage de trèfle. Le superphosphate et la potasse ont augmenté la proportion de trèfle. L'azote a réduit la proportion de trèfle et augmenté le nombre de mauvaises herbes. L'analyse botanique semble être indispensable pour obtenir une interprétation correcte des résultats d'expérience.

## TRAITEMENT DES SEMENCES CONTRE LA JAMBE NOIRE DES POMMES DE TERRE. John Tucker et E. W. Harber, Ministère de l'agriculture, Ottawa, Ont.

Les auteurs donnent les résultats de rapports obtenus sur 45,000 champs pendant une période de 5 années, comparant l'infection par la jambe noire dans les champs plantés avec de la semence non traitée et dans les champs plantés avec de la semence traitée au bichlorures de mercure ou à la formaline. Les deux méthodes réduisent les pertes dues à la jambe noire, mais en raison de leur coût elles ne sont pas à recommander, sauf pour les sols présentant des conditions particulièrement favorables au développement de la maladie.

# Wilfred Sadler

## 1883 - 1933

Wilfrid Sadler—born in Cheshire, England, and the son of James Sadler, O.B.E., etc., who for many years has been prominent in agricultural and dairy organization work in Great Britain—came to Canada in the year of 1912. From a minor position as assistant in Bacteriology at McGill (Macdonald College) he gradually and deservedly advanced to become Professor and Head of the Department of Dairying at the University of British Columbia.

The subsequent concentrated data regarding Professor Sadler's degrees, appointments and publications suggest, in part at least, the tremendous scope of his activities. But they do not and cannot indicate the quality of the brain which directed these activities, nor the beauty of the character of the man. That quality and that beauty were revealed in a large measure to those among us who were privileged to work with or for this remarkable genius.

We loved him for his personal charm and his humorous whimsicality; we admired his power of concentration and his extreme patience in detail work. Students and colleagues alike took pride in his achievements and in being associated with, and listening to, a scientist of outstanding qualities, an orator of great ability, a teacher of unusual perception and captivating methods of presentation, and a friend and counsellor of wide experience coupled with a sympathetic heart.

P.A.B.

*Degrees:* N.D.D., University of Reading, England, 1906; B.S.A., McGill (Macdonald College), 1915; M.Sc. (Gold medalist), McGill, 1917; Winner of International Education Board Fellowship (Rockefeller Foundation) enabling him to undertake special studies in Denmark and Sweden under Orla-Jensen and Barthel, 1926-27.

*Appointments:* Local Dairy Instructor in various English counties, 1907-10; Assistant and Lecturer at Midland Agr. and Dairy College, Kingston, Derbyshire, 1910-12; Assistant in Bacteriology at McGill (Macdonald College), 1912-13 and 1915-18; Instructor in Dairying at McGill, 1916-17; Associate Professor of Dairying at the University of British Columbia, 1918-21; Professor *ibidem* 1921-33.

*Publications:* TEXTBOOK: Bacteria as Friends and Foes of the Dairy Farmer. BULLETINS: Devonshire Clotted Cream; Bacterial Soft Rot of Turnips; The Bacteriology of Swelled Sardines; The Milk Supply of Montreal (with F. C. Harrison and A. Savage); The Grading of Butter and the Bacterial Content of the Same; The Spoiling of Milk (with Marion Mounce); On the Producing of Milk having a Low Bacterial Content, etc. PAMPHLETS AND MONOGRAPHS: The Kingston Cheese (with Alec Todd); A Note on an Organism producing a Burnt Milk Taste; The Production of a "Caramel" Odour and Flavour in Dairy Products by Streptococcus Lactis (Lister); Further Data on the Streptococcus Lactis Strain that produces "Caramel" Odour and Flavour in Dairy Products; Flavour Defects in High Grade Milk; Bacteria and Flavours; Coli Types and Ropy Milk (with J. D. Middlemass); Feed Flavor or Stable Odor in Milk caused by an Atypical Strain of Aerobacter Oxytocum; A Slime-Producing Organism from Water; The Discoloration of Halibut (with F. C. Harrison); Bacteria as affecting the Colour of Paper-Pulp (confidential report); A Preliminary Study of the Bacterial Content of Cheshire Cheese; The Classification of Certain Organisms isolated from Cheshire Cheese (with Orla-Jensen); Cheese Ripening Studies (with Blythe A. Eagles); Nitrogen Distribution in Kingston Cheese-Ripening, Nitrogen Requirements of Lactic Acid Bacteria (Parts I, II and Continuation); The Casein-Splitting Properties of Starters (with Chr. Barthel); Casein-Splitting Abilities of Lactic Acid Bacteria (with Blythe A. Eagles), etc.

# NOTES AND NEWS

## NEW FEATURE FOR SCIENTIFIC AGRICULTURE

### Quarterly Economic Section

Commencing with the present issue, *The Economic Annalist*, a review of agricultural business prepared by the Agricultural Economics Branch of the Dominion Department of Agriculture, will appear as a quarterly feature in *Scientific Agriculture*. Curtailment of funds available for the maintenance of *The Economic Annalist* as a monthly publication of the Agricultural Economics Branch forced its discontinuance during the summer months, and the present issue takes the place of Nos. 7, 8 and 9 covering July to September. An exceedingly appreciative response to a questionaire sent out to those whose names were on the mailing list justified the Economics Branch in making an effort to continue publication in some form. A suitable arrangement for publication as a part of *Scientific Agriculture* has been worked out which, it is hoped, will be mutually advantageous.

For those who are not familiar with *The Annalist* as it formerly appeared, it should be pointed out that it consists principally of material reporting the work of the Agricultural Economics Branch. This issue contains a study by Mr. J. Coke on government market control as demonstrated by coffee valorization in Brazil. Mr. A. E. Richards presents information on the business of co-operative dairy companies, and Mr. E. G. Grest reports on the cost of tractor operation in Western Canada. News items and reviews of current economic literature also have a regular place in *The Annalist*.

### Monthly Economic Analysis

An additional feature which should be of interest to all technical agriculturists is the section entitled "The Economic Situation." This consists of an interpretation from an agricultural point of view of annual and monthly index numbers of prices and production computed by the Dominion Bureau of Statistics. The table in this section gives the yearly averages from 1913 to 1932 and the monthly averages for the current year. This section of *The Annalist* will not only appear quarterly, but will be prepared monthly for *Scientific Agriculture* by an officer of the Economics Branch. Consequently, members of the C.S.T.A. will receive in their journal a monthly analysis of the agricultural situation and a quarterly section of short papers on pertinent economic topics.

### The Use of Index Numbers

The progress of both the physical and biological sciences has depended to a considerable degree upon the application of refined methods of measurement to the phenomena recorded. The science of economics has suffered from the difficulty of accurately measuring the highly dynamic material from which it must formulate its laws. The extensive use of index numbers as an accepted system of measurement of changes in price and production can hardly be said to date back to the opening of the present century, and their use in newspapers and popular periodicals is a post-war development. That they will become part and parcel of our everyday conversation in the near future is quite apparent. It is possible that within a few years they may form the basis of the valuation of the gold content of currency, replacing the less stable valuation based on the market price of gold itself. Such a system is already in effect in Sweden and some other European countries where average prices are held steady at the desired level.

It behooves us, then, to "know our index numbers." Warren and Pearson in *Prices* define index numbers as follows:

> "It is difficult to compare prices of different commodities directly. If wheat is $1.00 a bushel and coffee 10 cents a pound, one must make compari-

> son with previous prices before he can judge which of these is relatively high or low. The price of wheat may be compared with wheat prices for a previous period on a percentage basis, and similarly coffee prices may be compared with previous prices. If the wheat price is 90 per cent. of the previous price and coffee 110 per cent. of the previous price, the 90 may be compared with 110. These figures represent index numbers for prices of these two products.
>
> If index numbers are obtained for many commodities; and averaged, it is possible to judge the general price level. For example, the United States Bureau of Labor Statistics publishes an index number of wholesale prices of 784 commodities. Wholesale prices in 1920 more than doubled when compared with the five-year average before the war, but by 1932 were below the pre-war level. Usually the best way of judging the price of a particular commodity is to make comparison with the general price level as represented by some such index number as the one given above. For example, in June 1932, the index number for all commodities was 93. The index of the farm price of wheat was 41; of cotton, 36. Compared with other things, wheat and cotton were very cheap."

Many readers who have accepted the idea that index numbers represent an effort to provide a standard system of measurement for observing economic phenomena are somewhat disturbed to find the economist shifting the base year to suit what appears to be his own convience in making up his tables. The tendency of many of us is to use the years immediately preceeding the Great War as the base for our thinking on social and economic problems. Hence we like to see tables of index numbers based on 1913 as 100, or based on the five-year period 1910-14. We feel that this period represented "normalcy", and we doubt if we have ever been normal since.

There are, however, difficulties in basing all tables on pre-war years. In 1929 the Dominion Bureau of Statistics revised their indexes, using 1926 as the base year. Certain calculations going back as far as 1867 were also shown on the 1913 base for historical and comparative purposes. One of the main reasons for shifting the base to a post-war year was that the number of wholesale price series compiled by the Bureau had increased from 236 in 1913 to 502 in 1926. The wider range of products and the considerable change in their comparative volume or "weight" in the 1926 series gives a much more accurate picture of the price situation in a given year than do index numbers based on 236 commodities as they were produced in 1913. The price level for the year 1926 was about halfway between that for 1925 and 1927, and hence, the base year, 1926, is practically equivalent to the average of 1925, 1926, and 1927. Another reason for taking 1926 was that the United States Bureau of Labor Statistics in their index of wholesale prices of 784 commodities uses the same year. This makes it easier to study the close inter-relation of price movements in the two countries.

### Sound Economic Information Essential

It is hoped that the inclusion of *The Economic Annalist* as a regular feature in *Scientific Agriculture* will meet with the approval of members and subscribers. There has been a long-standing demand for articles of a more practical type from the point of view of the extension men and the commercial men. Practically all have been agreed that we should not encroach on the field of the farm journal, and it has been difficult to satisfy the demand.

We feel that the inclusion of economic survey material and the statistical appraisal of changing conditions from month to month should be of interest not only to field men but to practically all members of the C.S.T.A. It is one of our boasts in Canada that our research men are not divorced from the farmers' immediate fundamental problems. In fact, there are very few of our research men who are not in continual personal contact with farmers and students who are sons of farmers. It is not sufficient that technical agriculturists should be able to answer only questions on production in their special line of farm products. All of us are asked—if not as economists at least as supposedly well-educated and well-informed citizens—to express our opinions on current economic problem as they affect the farmer. We are asked these questions by farmers usually in informal conversation as we sit and talk man to man, with the rôle of scientist or administrative officer laid aside. This is often the time when real leadership can be given. But it can't be given on a basis of snap opinions formed from a perusal of the daily press. It is surely worth while for any man in technical agriculture to take the time to study the economic picture as it will be presented monthly in the issues of *Scientific Agriculture.* While the present issue has been held up while arrangements were pending regarding the publication of the *Economic Annalist,* future issues will appear promptly and the information will be more timely.

## C. S. T. A. GATHERING AT O. A. C.

A field day for Ontario sections of the C.S.T.A. was held at the Ontario Agricultural College at Guelph on September 30. The Niagara Branch and the Central Ontario Branch (Toronto) were guests of the O.A.C., C.S.T.A. and Faculty Club. A meeting was held in Memorial Hall where Dr. H. Barton, Dominion Deputy Minister of Agriculture spoke on the work of the National Advisory Committee on Agricultural Services, and H. L. Trueman reported on the Regina Convention and the World's Grain Exhibition and Conference.

About two hundred sat down to luncheon in Creelman Hall. Mr. J. B. Fairbairn, Deputy Minister of Agriculture for Ontario welcomed the gathering to the college, and Hon. Manning Doherty, formerly Minister of Agriculture for Ontario and at one time on the staff at Guelph spoke briefly. Following the luncheon the group enjoyed bowling, golf, and an exhibition of football. The ladies were the guests of the staff ladies at tea in Community House. Owing to the difficulty of holding a C.S.T.A. conference in any one province oftener than once in five or six years, the type of gathering held at Guelph is very valuable in bringing to members and their friends a picture of the activities of the Society. Quite apart from its value to the C.S.T.A., the day at Guelph was a pleasant reunion for many graduates of the old college, and the hospitality of Dr. Christie and the staff was greatly appreciated.

## WORLD'S GRAIN EXHIBITION AND CONFERENCE PROCEEDINGS TO BE PUBLISHED BY THE C.S.T.A.

Work is proceeding rapidly on the publication of the Proceedings of the World's Grain Exhibition and Conference. Editing is being done under the direction of the Programme Committee of which Dr. E. S. Archibald is Chairman and Mr. H. L. Trueman, Secretary. Mr. E. Rhoades, Secretary of the World's Grain Exhibition and Conference, has returned to Ottawa and is working with the committee on this task. Secretaries of the various affiliated societies and groups of the C.S.T.A. are preparing technical material from their sections. The printing is being done by the Mortimer Company of Ottawa who printed the Proceedings of the World's Poultry Congress and who have a reputation for doing excellent work on scientific material.

It has been decided, owing to the amount of material available, to print the Proceedings in two volumes. The first volume will contain the papers presented at the Open Sessions, discussions, prize winners in the competitive classes, and papers delivered at the Economic and Engineering Sessions of the Conference. It is expected that this volume will be available for distribution by December 15th at a retail price of $2.75 postapid. Orders may be sent direct to the C.S.T.A., Box 625, Ottawa. In view of the present developments in wheat marketing, the material in Volume I has become of world-wide interest. Papers delivered at the Morning Sessions were representative of many schools of thought and are valuable as expressions of opinions held previous to the signing of the world wheat agreement. The papers are of interest not only to the expert but to the layman who desires to have some knowledge on this problem of wheat distribution, a problem which is vitally affecting our economic stability.

The second volume will be largely biological in nature containing about 150 papers delivered at the technical sessions. It is hoped that this volume will be ready by February 15th. An announcement as to the price of this volume will be made later. Volume II will comprize one of the best collections of scientific papers ever assembled on the sciences relating to grain production. Owing to the cost of printing and illustrations in connection with this type of material, the price will be higher than the first volume but comparable with publications of this type. A limited edition only will be printed and those who have not taken out memberships in the Grain Conference and who desire to secure this volume would do well to order as soon as the price and date of publication are definitely announced. Those who took out membership in the Grain Conference will, of course, receive both volumes. Reprints of papers published will be available to authors at cost.

## JOINT C.S.T.A—O.A.C. BANQUET

The annual joint C.S.T.A.—Ontario O.A.C. Alumni Association Banquet will be held in the Tudor Room of the Royal York Hotel, Toronto, on Friday, November 24th, at 6.45 p.m. This annual event has steadily increased in popularity and last year a few late arrivals were unable to secure seats. Several committee meetings of a national character will be held during the week, and the attendance of men from the East and the West is assured. The banquet will be the place to renew old friendships. Tickets will be available from members of the C.S.T.A. and Alumni Association Executives and at the door. It is hoped that Hon. A. Godbout, Minister of Agriculture for Quebec and President of the C.S.T.A., will be able to take part in the programme. Rev. Fr. Leopold, vice-president of the C.S.T.A. and well-known to many of the members, expects also to be present.

Dean E. A. Howes of Edmonton will be the guest speaker. The men in the East have not had a chance to hear Dean Howes for some years, and his happy combination of reminiscences, philosophy, and sound advice will be welcome.

## POSITION OPEN IN DOMINION CIVIL SERVICE

Principal Clerk (Male), (Statistical), Agricultural Division, Dominion Bureau of Statistics, Department of Trade and Commerce at Ottawa, at an initial salary of $1920. per annum. By legislation this salary is subject to a deduction of 10% during the fiscal year beginning April 1, 1933. While the appointment to be made at the present time is temporary in nature, this examination will qualify for permanent appointment. For such appointment the initial salary of $1920. per annum will be increased upon recommendation for efficient service at the rate of $120. per annum until a maximum of $2400. has been reached.

Duties: To assist the Chief of the Agricultural Statistics Branch in the assemblies, analysis and publication of reports and estimates concerning the live stock industry; as required, to supervise a staff engaged in the collection and compilation of statistics related to the above and to cold storage; to specialize in statistical studies of agriculture, particularly in animal husbandry, and on a world basis, and to perform other related work as required.

Qualifications: Graduation from an Agricultural College of recognized standing with specialization in Animal Husbandry or Agricultural Economics, preferably with post-graduate work in Agricultural Economics including statistical research; full knowledge of live stock and of the live stock industry and of general agricultural economics; a knowledge of cold storage work, of the mechanism of the trade in live stock and of statistical methods in relation thereto; tact and good judgment.

While no definite age limit is set for this competition age may be a determining factor when making a selection.

An eligible list may be established which will be valid for the period of one year. Applications will be received up to November 10.

SCIENTIFIC AGRICULTURE

Vol. XIV NOVEMBER, 1933 No. 3

# IMPRESSIONS OF THE EAST MALLING RESEARCH STATION[1]

R. C. PALMER[2]
*Dominion Experimental Station, Summerland, B.C.*

The East Malling Station is considered by many to be the foremost horticultural research institution in the world. Established in 1912, with a Director and one other man comprising the entire staff, it has developed with remarkable rapidity until today there is a technical personnel of twenty-five, an administrative staff of eight, and a full time labouring force of over forty. There are 120 acres of land under very intensive cultivation. Modern laboratory buildings have been constructed and equipped with the precise apparatus essential for accurate scientific investigations. Most important of all, an atmosphere of enthusiasm and a spirit of service pervade the whole place. This is true not only of the internal organization of the Station, but also of its relations with other research institutions. The most cordial and harmonious relations are maintained with the Imperial College of Science and Technology, the John Innes Horticultural Institution, the Wye Agricultural College, and the Horticultural Research Station at Long Ashton.

The East Malling Station was originally established to solve practical problems encountered in the orchards and berry plantations of Kent. The active support received from practical growers throughout the County is ample proof that this function is being abundantly fulfilled. Nevertheless, much of the work of the Station is of a fundamental nature leading to discoveries of value to fruit growers the world over. In fact, one of the outstanding features of the organization of this Station is the harmony with which "applied" and "pure" science investigators work side by side under the same roof.

The foundation of East Malling's successful attack on horticultural problems seems to be an intimate knowledge of plant materials. From the first, it was fully realized that uniform plant material is a primary requirement for the application of scientific methods to horticulture. To this end much time and care were devoted to isolating varieties of berries true to name. This apparently simple and obvious procedure of isolating pure strains of berries brought an unexpected reward in that it revealed amazing variety partialities for different environmental conditions. Furthermore, it resulted in discovery of the fact that virus diseases are causing serious losses in the black current and raspberry plantations of England. This discovery paved the way for further investigations by Plant Pathologists and Entomologists, who were forthwith added to the staff of the Station.

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[1] A paper prepared for the Horticultural Group of the C.S.T.A., meeting at the World's Grain Exhibition and Conference, Regina, Sask., July 27, 1933.

[2] Superintendent.

The problem of securing uniform experimental material of the tree fruits proved even more difficult of solution, for few tree fruits can be readily propagated on their own roots with the result that the general practice has been to bud or graft the fruiting varieties on seedling root stocks. Lack of uniformity in these seedling stocks introduced a variable which the East Malling investigators set themselves to eliminate. After twenty years of concentrated effort they are presenting to the world clonal root stocks for practically all the deciduous fruits. In most cases these vegetatively propagated stocks are comparatively easy to raise, with the result that they promise to find their way rapidly into commercial orchards. It is in the orchards of research stations, however, that clonal stocks are of supreme importance for they make possible an experimental technique combining accuracy with the use of comparatively small units of plant material.

The emphasis placed on uniformity of plant material at the East Malling Station naturally resulted in the development of a Propagation section. This section conducts investigations into the most economical methods of producing uniform plant material. It is also charged with the task of providing suitable experimental material for the use of all other sections on the Station. Furthermore, it now furnishes large quantities of material to commercial nurserymen and to experimental institutions throughout the world. In fact, the excellent reputation of the East Malling Station is due in large measure to the success which has attended the efforts of the Propagators to produce uniform plant materials of a superior grade.

The performance of trees propagated on clonal root stocks has proved beyond question that the behaviour of fruit trees is influenced by the root stocks on which they are worked. There still remains the problem of the fundamental cause of these stock effects. It seemed probable that the primary source of stock influence might be found in the spheres of Plant Physiology or Bio-chemistry. Accordingly, the services of Physiologists and Biochemists were enlisted in the hope that they might be able to ascertain the principles underlying the phenomena observed by the Pomologists. That this hope is justified has already been demonstrated by a valuable contribution of Physiology to the problem of "speeding up" vegetative propagation of root stocks. It has been discovered that when the base of a stem is protected from exposure to light from its early stages of growth, rooting takes place comparatively freely from this "etiolated" portion of the stem. Discovery of this general principle has facilitated the propagation of a wide range of stocks which had previously proved almost impossible to raise by vegetative means.

Although East Malling is primarily a research rather than an advisory institution, the tendency of growers to go to the original source for information has necessitated the formation of an extension section. This section organizes all educational activities, but one of its chief duties is to protect the research men from too much disturbance in the way of correspondence and advisory visits. A "guide demonstrator" relieves the technical investigators from the duty of repeatedly explaining the purpose, methods and results of their work to the constantly increasing number of interested people who visit the Station.

Finally, a statistical section has been developed to assist in the planning of experiments and in the interpretation of the results secured. This section has already proved its worth and there are evidences that it will play a major rôle in development of the "science" as contrasted with the "art" of horticulture.

Thus, various specialists have been taken on the staff of the Station as the complex nature of the problems under investigation has become apparent. It is the practical service already rendered by the Station, however, which has made it possible to secure the funds necessary to conduct the fundamental researches which are now in progress.

The Station is financed mainly by the British Ministry of Agriculture and the Empire Marketing Board, but some funds are contributed by various County Councils and industrial concerns. There is also a membership scheme through which growers contribute directly to the upkeep of the Station. Sale of produce is an additional source of funds. Furthermore, there is the nucleus of an endowment fund designed to provide an independent source of revenue which can be drawn upon in times of emergency.

The affairs of the Station are ultimately supervised by a "Committee of Management" made up of representatives of the Ministry of Agriculture, County Councils, research institutions, the National Farmers' Union, the Horticultural Trades Association, and the Institute of Brewing, an even balance being maintained between the number of "scientific" and "practical" members. An Executive Committee drawn from the above assists in deciding matters of policy, finance, etc., but most of the responsibility for operation of the Station falls on the Director and on the Chairman of the Executive Committee who pays almost weekly visits to the Station to discuss problems of management.

Although the activities of the Station are restricted almost entirely to study of fruit problems, the staff is organized in sections dealing with Pomology, Physiology, Pathology, Entomology, Bio-chemistry, Propagation, Statistics, Extension and Administration. In addition, the Imperial Bureau of Fruit Production comes under the supervision of the Director of the East Malling Station.

Pomology is by far the largest section. It is headed by the Director who is primarily a Pomologist, although he is a man of such keen insight and wide sympathies that investigators from all sections instinctively come to him for guidance. The Farm Manager also belongs to this section. He occupies a "key" position in the organization of the Station in that he is the intermediary between the technical investigators and the labouring force. It is his business to ensure that research work takes precedence over general farm operations when there are conflicting demands for labour. At the same time he is responsible for economical management of the farm. This dual duty necessitates a thorough knowledge of both "scientific" and "practical" horticulture—a combination seldom found in one man. In fact, the Farm Manager's responsibilities are second only to those of the Director. He has supervision over all cultural operations which leaves the technical investigators free to concentrate on their special problems.

The "Assessor of Market Qualities" is another important member of the Pomology section. He supervises all picking and packing operations and also attends to the actual sale of the produce. He is charged with the double duty of selling the produce at a remunerative price and at the same time securing accurate data on the influence of cultural, harvesting and packing procedure on the returns secured.

The special investigators studying pruning, thinning, root growth, plant nutrition and plant breeding also belong to the Pomology section. So, too, do the Recorders, who are largely responsible for the accurate and comprehensive records on which the good reputation of the Station has been built.

The regular schedule of operation includes a weekly "Recorders' Meeting" of which the Farm Manager is Chairman and the senior Statistician is Secretary. This meeting, usually attended by the Director and the entire Pomology staff, provides a "clearing house" for information. It is held ostensibly to formulate the Pomology programme for the following week, but almost any subject may come up for discussion and any member of any section may attend and ask for special assistance. The presence of the Statistician ensures that all necessary records will be taken during the coming week and the presence of the Farm Manager ensures co-ordination of research and general cultural activities.

The year's programme of each section is discussed and formulated during the winter months, first within the section or sections concerned, and finally at a general meeting of the entire staff. To further ensure that the members of each section are familiar with the investigations which are being conducted by their colleagues in the other sections, general staff meetings are held twice a month during the winter. At these meetings papers are presented outlining the methods of procedure and the progress made towards solution of the various problems under investigation. Discussion is invited and exchange of views is often quite animated. Friendly intercourse between the members of the various sections is also encouraged at meal times when all meet under the harmonising influence of food and liquid refreshment. The desire to be mutually helpful is so strong that investigators seem glad of the opportunity to lend equipment to each other!

The regular working hours of the technical staff are from 9 to 5 with 1 hour off for lunch, and 15 minutes off for afternoon tea. There is no checking in or out, but the tendency is to work overtime rather than to take undue advantage of the freedom allowed. In fact, some of the most valuable discoveries made by the Entomological staff are the result of staying up all night with a flash light observing the nocturnal habits of insects. Such enthusiasm is doubtless the fruit of a farsighted policy which aims to give every member of the staff a keen interest in his work and in the general welfare of the Station. Even the youngest laboratory assistant is encouraged to carry out some special project which is his very own responsibility. The Director, Mr. R. G. Hatton, makes it plain that he is at the service of each and every member of his staff. In return, he receives their wholehearted support. In fact, one cannot escape the conclusion that the East Malling Research Station is the product of one man's vision, enthusiasm and personality. In a truly miraculous manner, the Director, by the strength of his own character, has welded many diverse and conflicting elements into a unified, efficient and remarkably contented staff.

# STUDIES IN PLANT NUTRITION

## A REPORT OF EXPERIMENTS IN PROGRESS AT THE LONG ASHTON RESEARCH STATION

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[Received for publication October 5, 1933]

Long Ashton is justly famous for achievements in the field of plant nutrition. These achievements have been made possible by the fact that pomologists and chemists have worked side by side in their efforts to solve practical problems encountered by the grower.

In briefest outline the procedure has been:

1. Grow plants in clean sand which permits accurate control of the nutrient supply.
2. Record the influence of modification of the nutrient supply on the behaviour of the plants.
3. Use the knowledge so gained for the diagnosis of symptoms observed in the plantation.
4. Check the accuracy of the diagnosis by field trials.

The most striking success of this procedure has been in connection with the condition known as "Leaf Scorch". A few years ago this condition, characterized by a scorched appearance of the leaves, weak growth and low yields, was prevalent in many English orchards and berry plantations. Pathologists had failed in their efforts to ascertain the cause of "Leaf Scorch", and fertilizer trials on a field scale had given inconclusive results. Pot experiments carried out at Long Ashton, soon showed that plants grown under conditions of potash deficiency developed symptoms similar to those exhibited by plants suffering from "Leaf Scorch". Subsequent field trials have proved that in most cases, "Leaf Scorch" can be overcome by heavy applications of sulphate of potash, although three or more years usually elapse before the full benefits of the fertilizer are realized. The general recommendation at present is to apply sulphate of potash annually at the rate of 500 pounds per acre, the material being broadcast on the surface of the soil in the autumn. Growers are being cautioned against the use of forms of potash containing chlorine, as these have been found to cause serious injury to some crops, especially gooseberries.

In view of the striking benefits which have followed the application of potash to English fruit plantations, it is remarkable that so many American investigators have reported negative results from the use of potash in orchard fertilizer experiments carried out in the United States. In this connection it is noteworthy that the most obstinate cases of "Leaf Scorch" have occurred on shallow soils underlaid with hard pan or where there is a high water-table. It is under somewhat similar conditions that such troubles as "Cork" and "Drought Spot" are most prevalent in the Okanagan Valley.

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[1] Superintendent.

The Long Ashton controlled nutrient experiments have also provided valuable indications as to the manner in which deficiencies of nitrogen, phosphorus, calcium and magnesium are likely to reveal themselves in plant behaviour. The symptoms of nitrogen starvation are, of course, well known to many Canadian orchardists. Even under English conditions there is ample evidence that it is often advisable to apply nitrogen to fruit plantations. English orchards also provide plenty of proof, however, that the application of unduly large amounts of nitrogenous fertilizers may produce disastrous results. Thus injuries due to potash deficiency are greatly intensified by the application of nitrogen.

Potted trees fed on a nutrient solution deficient in phosphorus have exhibited very marked evidence of phosphorus starvation. It appears significant, however, that these symptoms have not yet been observed in the orchard, even on trees growing in locations where the soil is extremely low in phosphorus. Apparently fruit trees are especially well equipped for securing their phosphorus requirements from the soil.

The Long Ashton experiments indicate that the ratio of potash to nitrogen in the nutrient supply not only influences the growth and productivity of apple trees but also materially affects the quality of the fruits produced. In studying this phase of the problem fruit from trees growing under various nutritional conditions has been kept in storage. It has been found that Bramley apples grown under conditions of low potash supply have a very long life at common storage temperatures and a very short life when kept at a temperature of 32° F. owing to increased susceptibility to low temperature breakdown.

The storage programme includes a study of the influence of such factors as root stock, bark ringing, pruning, thinning, fertilizer treatment, time of picking, etc., on the keeping quality of fruit. Chemical analyses are made in an attempt to ascertain the extent to which storage behaviour is correlated with chemical composition. Extremely interesting results have been secured which indicate the complexity of the problem and the dangers of attempting to generalize from less comprehensive experiments. The evidence secured suggests that while keeping quality is undoubtedly correlated with chemical composition, especially as regards the amount of nitrogen and sucrose present in the fruit, the relation is by no means a simple one. In fact apples of apparently similar nitrogen and sucrose content produced by "grass culture" and "bark ringing" respectively have behaved very differently in storage. It is believed that the form in which the nitrogen is present may be the key to keeping quality and special methods of analysis are being developed to test this theory.

One interesting point brought out by these storage investigations is that an apple developed from the central flower of a cluster has a very different chemical composition from an apple produced by a lateral blossom. Strangely enough this appears to hold true though only one apple is permitted to develop from each of a number of flower clusters. Since the apples produced by lateral flowers have been found to be sweeter, firmer and more resistant to rots, it is suggested that it may be worth while to remove the central fruits during the operation of thinning.

Intensive soil and pomological surveys form an important feature of the plant nutritional investigations at Long Ashton, the aim being to ascertain the extent to which soil characteristics are reflected in plant performance. In these surveys, a chemist and a pomologist collaborate, the chemist classifying the soils according to physical and chemical characteristics, drainage conditions, etc., and the pomologist securing a detailed record of plant behaviour. Emphasis is placed on the importance of giving the chemist and pomologist equal authority and making each of them responsible for his part of the programme. They are encouraged to consult each other frequently, but it is considered advisable that they make their field observations separately, it being thought that too close association might lead them to see correlations where in fact none existed.

In practice it has sometimes proved very difficult to distinguish between the effects of adverse soil conditions and the effects of poor management. Nevertheless, the surveys have revealed that there is commonly a very close correlation between soil characteristics and plant growth. It has been found that certain fruits and even certain varieties have very definite soil preferences. This information should prove invaluable as a guide to future planting. The data secured also provide a basis for decisions as to whether, in existing plantations giving poor performance, it is worth while to apply remedial measures or wiser to devote the land in question to more adaptable crops.

Combined pomological-chemical attack of fruit problems as exemplified by the Long Ashton work offers great promise as a means of ascertaining the fundamental cause of so-called physiological diseases. Close association of chemists and pomologists ensures that the chemist acquires some of the sympathetic insight of the pomologist and conversely the pomologist develops a very real appreciation of the value of the precise methods employed by the chemist. This method of attack has already been used to good advantage at the Summerland Station in the study of Red Strains of the Delicious apple. Investigations of this type are of great practical as well as scientific importance and it is most desirable that they be continued and extended even in the face of reduced appropriations.

The eggplant wilt organism is capable of living in the soil for a considerable time, thus providing inoculum for the infection of susceptible hosts.

## CULTURAL INVESTIGATIONS

*Cultural characters.*—On the surface of artificial media the fungus forms a soft, loose, white cottony mass of hyphae (Plate II, Figure 8) producing verticillate conidiophores which bear spherical to ovate conidia in profusion (Plate II, Figure 11). The typical congregation of spores in droplets of moisture is visible in Plate II, Figure 12. There are formed within the medium a large number of thick-walled, short, dark, multiple-celled bodies or pseudosclerotia which give the culture a dark appearance (Plate II, Figure 15). The quantity of these black bodies varies considerably, but they have been observed in all isolations.

*Temperature and acid relations.*—Although the optimum temperature for the growth of the pathogen on potato dextrose agar is between 21°C and 24°C, it will grow at temperature as high as 34°C and as low as 8°C. At 28°C to 30°C growth is considerably retarded and produces a heavy white tuft of mycelium with few pseudosclerotia. Above 31°C it is extremely slow, the colony has a definite compact cerebroid formation and no pseudosclerotia are produced. At 34°C the first visible growth appears after an incubation period of three weeks. At temperatures below the optimum the colony is normal in appearance but the growth is greatly reduced.

The organism's response to variations in the reaction of potato dextrose decoction adjusted with hydrochloric acid and sodium hydroxide solutions shows approximately equal growth within the range of pH 9 to pH 5.4. At pH 4.5 growth is essentially similar but there is less pseudosclerotial development, and between pH 3.9 and pH 2.3 only meagre growth immediately surrounding the original inoculum. These pH tolerances coincide with those recorded by Haenseler (*11*).

*Fungus isolations.*—In 1918 Jagger and Stewart (*14*) isolated a species of Verticillium from the fibro-vascular bundles of all parts of wilted eggplants including the fruit. Haenseler (*7*) and (*8*), stated that the fungus hyphae were noted in the secondary roots, primary roots, main stem and secondary branches to within a few inches of the growing tip but no hyphae were found in the pedicel of the fruit, and tests proved that the wilt disease was not transmitted through the seed either externally or internally.

During the course of the present investigations, isolations from a large number of plantings of the vascular tissues from all parts of diseased plants proved conclusively that the pathogen can be isolated from all parts of the host including the seed (Plate II, Figure 9). Positive isolations are most frequently obtained from tissues which show intense vascular browning.

The following technique was always used when making isolations from host tissues. The part of the plant to be used was thoroughly washed and sterilized in mercuric chloride. A portion of the host tissue was removed aseptically and planted on a potato dextrose 2.5% agar slope which had previously been acidified with two drops of a 25% lactic acid solution, and the cultures incubated at room temperature.

In connection with the presence of the pathogen within the fruit, one series of isolations will be of interest here. From a field experiment, the

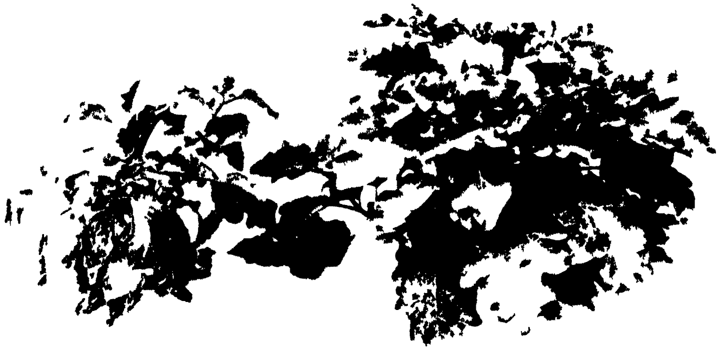

Figure 1 Eggplants growing together in the same field the one on the left is typically diseased while the other is healthy

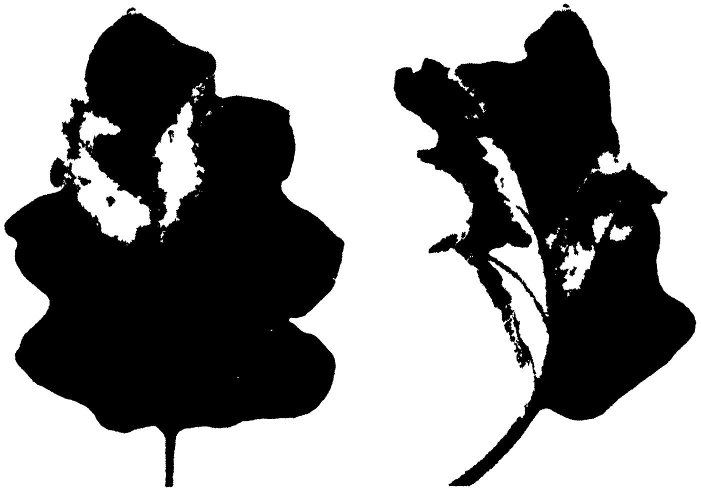

Figure 2 Leaves from diseased eggplants showing two progressive stages in the wilting of the tissues

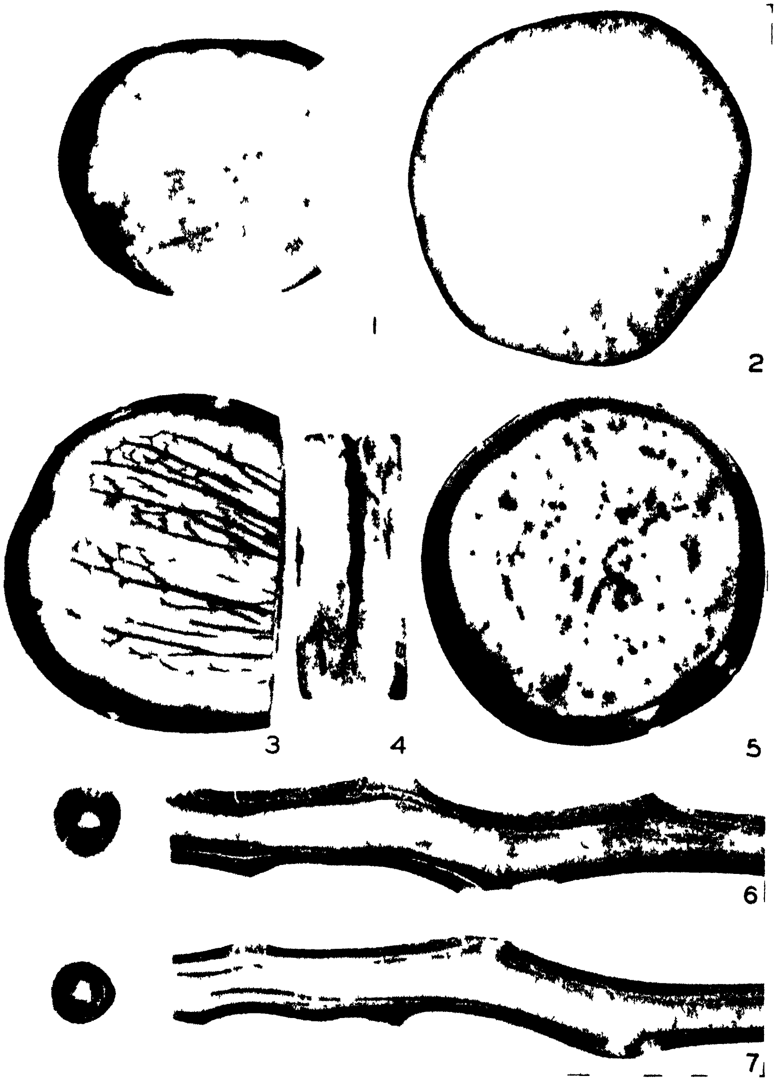

PLATE I

Figures 1 and 2 The appearance of the fruit from healthy plants in longitudinal and cross sections

Figures 3, 4 and 5 The typical browning of the vascular tissues in the fruit of wilt infected plants

Figures 6 and 7 Severe vascular browning in the stem of a diseased plant and the absence of abnormal discoloration in a healthy specimen respectively The dark lines in the healthy specimen are due to the presence of dark green parenchymatous tissue inside the vascular ring

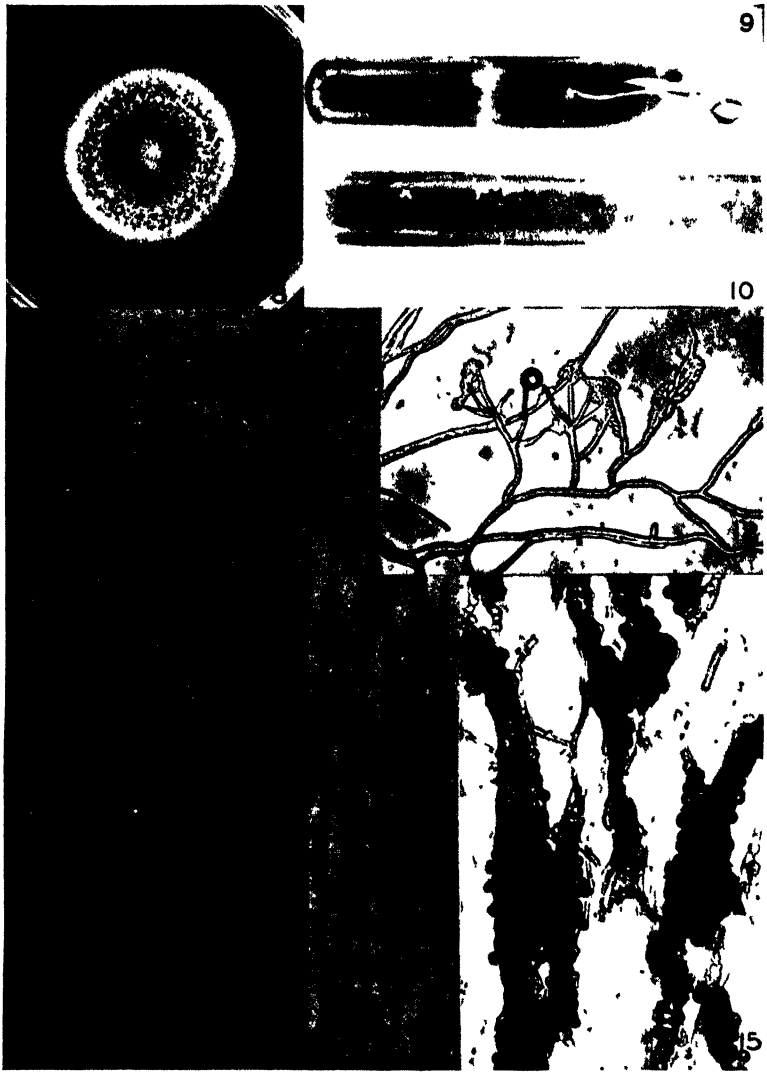

Plate II.

Figure 8. Ten day old colony of *Verticillium Dahliae* Kleb., on potato dextrose 2.5 per cent agar incubated at 20°C.

Figure 9. The pathogenic fungus growing from an eggplant seed which has also germinated The seeds were removed aseptically from a fruit which showed severe vascular browning and planted on a potato dextrose agar slope.

Figure 10. Plantings of tissue from diseased fruits showing the growth of the fungus from the broken ends of the vascular strands.

Figure 11. Spores of *V. Dahliae* X 350.

Figure 12. Typical aerial growth of the fungus showing the verticilliate branching of, and profuse spore development from, the conidiophores

Figures 13 and 14. Longitudinal sections of the vascular tissue from the stem of a wilted eggplant showing the mycelium and spores within the vessels of the host.

Figure 15. The black pseudosclerotial bodies which are produced in artificial medium, and give the cultures their dark appearance.

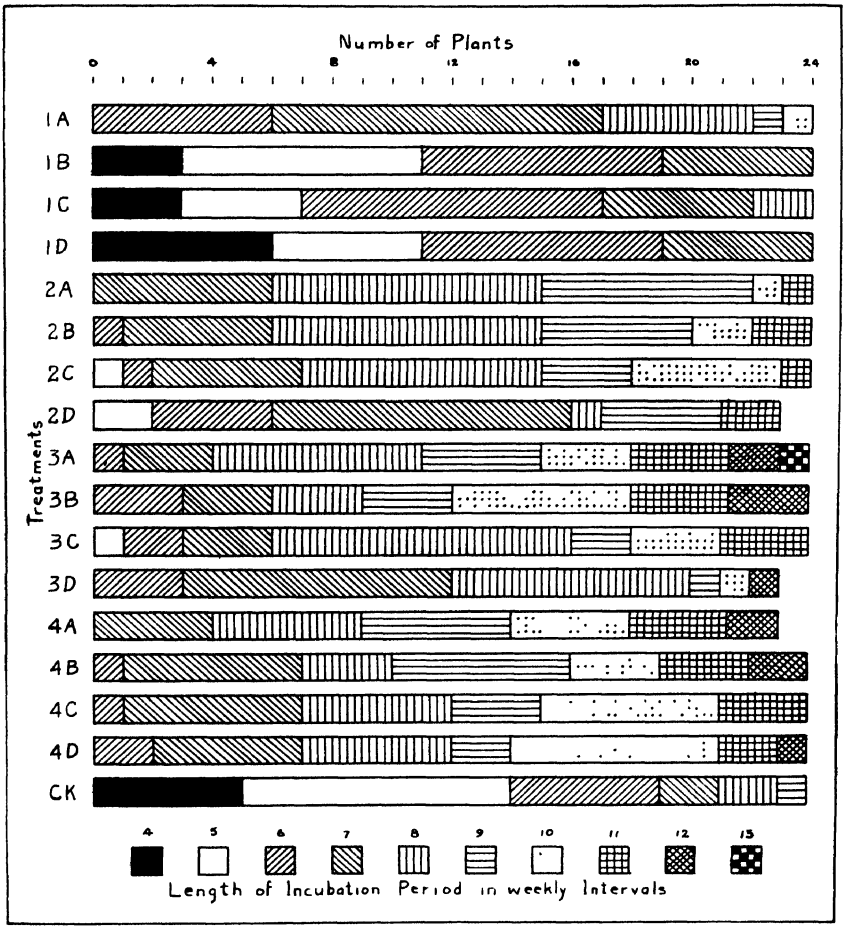

Figure 3. Graph showing the retarding effect of applications of mercuric chloride upon the development of Verticillium wilt in the field.

fruits from 38 out of 350 wilted plants showed vascular discoloration. Eighty-four per cent of these gave positive isolations of Verticillium (Plate II, Figure 10). In addition to the above, isolations from twenty-five fruits which showed no vascular discoloration gave entirely negative results. Eight of the fruits showing vascular browning were sufficiently mature to have formed seed and the plantings from these seeds returned the pathogen in six cases. This clearly demonstrates the possibility of seed transmission.

## SOIL TEMPERATURE RELATIONS

Bewley (*2*) mentions that the optimum temperature for the development of Verticillium wilt of the tomato is from 70° to 73°F. (21° to 23°C.), while the minimum is 60°F. (15°C.), and the maximum 75°F. (24°C.). Guba (*6*) states that the wilt organism cannot infect eggplants at temperatures above 77°F. (25°C.), and Ludbrook (*15*) reports the temperature range for *V. Dahliae* as being 12° to 30°C.

In view of the above, experiments were conducted to determine the effect under greenhouse conditions of various soil temperatures upon the infection capability of the eggplant wilt pathogen.[3] The plants tested were grown in constant temperature water tanks, kept within the required range by either cool running water or thermostatically controlled electric heating.

TABLE 1.—INFECTION RESULTS OBTAINED BY GROWING EGGPLANTS AT DIFFERENT SOIL TEMPERATURES.

| Temperature °C. | | No of plants inoculated | Incubation period in days | Per cent infection | Dates of experiment |
|---|---|---|---|---|---|
| Average | Range | | | | |
| 11.3 | 10–14 | 6 | 27 | 16.6 | Jan 1—Feb. 19 |
| 15.2 | 11–19 | 6 | 18–36 | 50.0 | Apr. 22—June 10 |
| 18.9 | 17–21 | 6 | 22–32 | 100.0 | June 21—July 23 |
| 20.8 | 18–23 | 6 | 61–71 | 100.0 | Apr. 1—June 10 |
| 21.6 | 21–23 | 6 | 62–76 | 33.3 | Jan. 1—Mar. 15 |
| 25.0 | 25–26 | 6 | 18–32 | 100.0 | June 21—July 23 |
| 30.0 | 30 | 8 | 16–53 | 100.0 | Jan. 9—Feb. 28 |
| 35.0 | 35 | 6 | 0 | 0 | Apr. 1—July 4 |

The young seedlings to be used were transplanted when about 4 inches high into sterilized soil in the metal containers in the tanks and allowed to become established for a few days before being inoculated. Temperatures were taken morning and evening throughout the duration of the tests. The tanks had accommodation for 8 plants and in all but one test, 6 of these were inoculated and the remaining 2 left as checks in order to observe the effect of the temperature upon healthy growth. Plants growing in pots in close proximity to the tanks were kept as additional checks to determine the normal host reactions to the pathogen at the time of year the experiments were being conducted.

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[3] In all the infection experiments described in this paper, plants were grown from seed in steam sterilized compost, planted in sterilized pots and inoculated by the application of a spore suspension to the surface of the soil. The inoculum was obtained from monosporous cultures of the pathogen grown on oat hulls mixed with water and thoroughly rubbed through a 40-mesh sieve to remove the excess culture medium.

To maintain a temperature of 30°C. and over, it was found necessary to cover the soil containers with a layer of non-absorbent cotton about 2 inches thick, to minimize the cooling effect of the air as the greenhouse temperature during the test was from 20°C to 23°C. By this means the soil temperature anywhere in the container could be kept to within one degree of the temperature of the water in the tank.

Due to the proximity of the checks to the inoculated plants a few of the former became infected by splashing from the inoculated series during watering operations. Series were conducted at temperatures ranging from 11.3°C to 35°C.

The results of the experiment show clearly that the organism used is capable of producing wilt in eggplants growing at soil temperatures between 11.3°C and 30°C, but not at 35°C. The small percentages of infection obtained from the two lowest temperatures may be explained by the fact that within that range the plants exhibited sub-normal growth. No explanation is evident for the low percentage of disease developing at 21.6°C.

## FERTILIZER EFFECT

The fact that eggplants in the field sometimes outgrow the disease suggested that the addition of certain fertilizers to growing plants might in some way affect their reaction towards the wilt.

In this connection an experiment was set up in the greenhouse with 64 plants growing in 8-inch pots of sterilized soil. The series was divided into 8 groups of 8 plants, 7 of the groups received equal applications of fertilizer of a different formula and the eighth remained untreated as a control.

The chemical elements used were nitrate of soda, superphosphate and muriate of potash. These compounds were used singly and in the following combinations: 4-8-4, 4-4-8, 4-8-8 and 4-4-12. The fertilizers were added to the soil at weekly intervals and in such quantities that an equal amount of available food material was applied to each plant. The pure nitrate of soda was found to be somewhat caustic to the plant, therefore the quantity of this material used was halved.

TABLE 2.—THE EFFECT OF FERTILIZER ON EGGPLANT WILT.

| Fertilizer | Incubation period | | Per cent disease |
|---|---|---|---|
| | Shortest | Longest | |
| Nitrate of soda | 30 | 47 | 62.5 |
| Superphosphate | 29 | 56 | 87.5 |
| Muriate of potash | 19 | 37 | 100 |
| 4-8-4 | 21 | 35 | 100 |
| 4-4-8 | 25 | 39 | 100 |
| 4-8-8 | 22 | 43 | 100 |
| 4-4-12 | 21 | 35 | 100 |
| Control | 15 | 31 | 100 |

The plants were potted on March 25, the first application of fertilizer made on March 28 and three subsequent weekly applications were made before the plants were inoculated. After inoculation four additional applications were made, the last on May 29. In each of the first three applications 1 gram of available food material was added and in the last five, 2 grams.

The group treated with pure nitrate of soda showed 62.5% diseased plants but the remaining three plants died as a result of the treatment. One plant of the superphosphate group showed no symptoms at the conclusion of the experiment, July 4th, and all remaining plants succumbed to the disease.

## THE APPLICATION OF FUNGICIDES TO THE SOIL

In the endeavour to discover some means for controlling this disease, it was thought possible that a fungicide might be found which, when added to the soil, would interfere with the activities of the pathogen.

Considerable research has been conducted in this connection with maladies caused by soil inhabiting parasites with various degrees of success. Williams (*20*), when working with Verticillium wilt of tomatoes tried many chemicals, some of which showed beneficial results.

As an introduction to these studies, a number of fungicidal chemicals were tested to determine their killing effect on the eggplant wilt pathogen in culture. The procedure followed was to flood cultures of the fungus growing in test tubes on potato dextrose agar with different concentrations of these chemicals, and to make transfers from these tubes at various intervals to new slants of culture medium to ascertain whether or not the organism was still alive.

The following self-explanatory table gives a resumé of the results obtained.

TABLE 3—THE KILLING EFFECT OF CHEMICALS UPON THE EGGPLANT WILT FUNGUS IN CULTURE

| Compound | Percentage strength of solution | Length of treatment in days | Per cent killing effect |
|---|---|---|---|
| Lime sulphur | 5 | 7 | 50 |
| Sodium chloride | 10 | 7 | 0 |
| Cheshunt compound* | 1 | 1 | 100 |
| Calcium chloride | 10 | 7 | 0 |
| Copper sulphate | 5 | 1 | 100 |
| Calcium monosulphide | 5 | 7 | 0 |
| Ferrous sulphate | 5 | 7 | 0 |
| Aluminum sulphate | 10 | 7 | 0 |
| Zinc sulphate | 5 | 7 | 0 |
| Iron oxide | 5 | 7 | 0 |
| Phenol | 10 | 1 | 100 |
| Phenol | 1 | 7 | 0 |
| Formalin | 1 | 1 | 100 |
| Mercurous chloride | .5 | 4 | 100 |
| Mercuric chloride | .05 | 2 | 100 |
| Yellow mercury oxide | .25 | 4 | 100 |
| Semesan | .1 | 2 | 100 |
| Copper carbonate | 5 | 4 | 100 |
| Paradichlorobenzol | Conc. atmos. | 84 | 0 |

*This material is prepared by grinding and thoroughly mixing together 2 parts copper sulphate crystals and 11 parts ammonium carbonate and allowing the mixture to stand 24 hours before use.

The compounds which proved to be fungicidal in the foregoing tests were applied to the soil in which eggplants were growing in order to ascertain the quantities which could be applied to a plant without materially affecting its growth.

To plants growing in 9-inch pots of unsterilized soil 100 c.cs. of each solution were applied at bi-weekly intervals for a period of seven weeks, or until the plants had been killed. At the end of this time, all remaining specimens with the exception of the checks were inoculated with the pathogen and infection results recorded.

In addition to the above, several series of control tests were carried out with a variation in both the strengths and quantities of chemicals used, in order to determine the efficacious applications.

The data recorded from these investigations showed that copper sulphate phenol and formalin could not be used on account of their toxicity to the host. Only mercuric chloride, mercurous chloride and yellow oxide of mercury showed definite possibilities for controlling the disease but the latter two had to be disregarded on account of their high cost, leaving mercuric chloride as the only substance tested which could be used as a commercial means of control.

In testing mercuric chloride four series of greenhouse experiments were carried on with equally promising results, only one of which will be described in detail here.

The eggplants used were grown throughout the experiment in steam-sterilized soil. Seed of the New York Purple variety was used and when the plants were about 4 inches high, they were transplanted to seven-inch pots. The inoculum was added to all pots, with the exception of the control block, one week prior to the inception of the experiment in order to simulate natural conditions as nearly as possible. Each mercuric chloride application was administered as 200 c.cs. of a one-fifth per cent solution of the chemical in water poured on the surface of the soil in the pot.

The treated portion of the experiment was divided into four series 1, 2, 3 and 4, corresponding to the number of applications of chemical each pot was to receive. Each of these series was again divided into four groups, A, B, C and D. In series 1, A received the application immediately prior to setting out the plants and B, C and D respectively, three, seven and fourteen days after transplanting. In the remaining three series all plants received one chemical application immediately prior to setting out the plants and additional ones at, (A) semi-weekly, (B) weekly, (C) fortnightly, and (D) three-week intervals thereafter. Series 5 and 6 were inoculated check and uninoculated control respectively.

Daily observations were made to record the appearance of wilt in order to determine the retarding as well as the controlling effects of the various groups of treatments.

An examination of the results above shows that there was a slight degree of control obtained where a single application of the chemical was made immediately prior to setting out the plants, 1A, but where the application was delayed for even as short a time as three days, infection had apparently occurred before the chemical had been added, 1B, 1C and 1D. In the cases

TABLE 4.—RESULTS OBTAINED IN CONTROLLING EGGPLANT WILT BY THE APPLICATION OF VARIOUS QUANTITIES OF MERCURIC CHLORIDE TO THE SOIL.

| Treatment | No of plants | Days between planting and final treatment | Incubation period in days | | Per cent healthy plants |
|---|---|---|---|---|---|
| | | | Shortest | Longest | |
| Control | 20 | — | 75 | 86 | 70 |
| Check | 12 | — | 19 | 30 | 0 |
| 1A | 8 | — | 64 | 82 | 37 5 |
| 1B | 8 | 3 | 21 | 38 | 0 |
| 1C | 8 | 7 | 19 | 29, 82* | 0 |
| 1D | 8 | 14 | 17 | 28 | 0 |
| 2A | 8 | 3 | 73 | 82 | 75 |
| 2B | 8 | 7 | 45 | 87 | 62 5 |
| 2C | 8 | 14 | 82 | 82 | 75 |
| 2D | 8 | 21 | 45 | 87 | 50 |
| 3A | 8 | 7 | 61 | 86 | 62 5 |
| 3B | 8 | 14 | 82 | — | 87 5 |
| 3C | 8 | 28 | 75 | 86 | 75 |
| 3D | 8 | 42 | - | — | 100 |
| 4A | 8 | 10 | 86 | — | 87 5 |
| 4B | 8 | 21 | 86 | — | 87 5 |
| 4C | 8 | 42 | 48 | — | 87 5 |
| 4D | 8 | 63 | 20 | 86 | 62 5 |

*In this case, seven of the plants had become diseased after 29 days, but for some reason the eighth plant did not exhibit disease symptoms until 82 days after inoculation

where more than one application was made, a definite measure of control was obtained. The results are fairly constant but there is a slight increase in control shown in the three and four treatment series over that which received only two. Also in two groups, 2D and 4D which received applications at 3-week intervals there was an increase in disease over other members of the groups which had received the same amounts of the chemical with the treatments at closer intervals. Again it will be noticed that in the series which received multiple applications and where some infections occurred, most of the disease appeared a considerable time after the final addition of the fungicide.

Hurst and Howatt (*13*), have shown that the fungicidal effect of mercuric chloride is considerably reduced by its chemical reaction with the soil and since there must have been a certain measure of contamination of the pots from outside sources, as shown by the fact that 30% of the control plants became diseased, it is probable that the majority of the infections in plants which received more than one treatment took place after the mercuric chloride in the soil had been reduced to such an extent that its action was no longer fungicidal.

An experiment similar to that just described was carried on under field conditions using 24 plants in each plot. The quantity of the chemical added in this case, however, was 300 c.cs. per application, an increase of 50% over that applied in the greenhouse. Immediately before the solutions were added to the soil, depressions about four inches in diameter were made around the bases of the plants in order to concentrate the chemical in the vicinity of their roots. The same number of plots was used as in the greenhouse and the number of, and intervals between the chemical treatments were identical.

Although the field was known to be heavily contaminated with the wilt fungus, 18 of the 24 plants in each plot were artificially inoculated. As the experiment progressed and the results were recorded no visible difference appeared between the two sections; therefore in the compilation of the final results they were not separated.

Weekly observations on the presence of disease in the plots were commenced on July 3, three weeks after the inception of the experiment but the first symptoms of the disease did not appear until one week later. In Figure 3, the additional plants showing symptoms of wilt during each week are recorded as having wilted after an equal incubation period.

The results obtained from the field experiment as illustrated in the graph show that there was a definite retarding effect upon the progress of the disease where even a single application of the chemical was made prior to setting out the plants. Where the application was not made until after transplanting, 1B, 1C and 1D, a large amount of disease developed early in the growing period. Additional applications of the chemical after planting showed an increased retarding effect except in two cases 2D and 3D where there was a lapse of three weeks between treatments. It seems possible that the crop may derive some benefit from the application of mercuric chloride solutions around the bases of the plants immediately after periods of cultivation or heavy rainfall when the distribution of inoculum is most liable to take place.

## Biologic Control

During the past two years a large number of isolations of soil inhabiting organisms have been made. Each of these which showed an antagonistic reaction towards Verticillium when grown with it in Petri dishes was saved and recultured for use in the experiments. The fungous organisms were grown on sterilized oat hulls in 125 c.c. Erlenmeyer flasks while the bacteria were grown in tubes of potato dextrose decoction.

Before the young eggplants were planted into 8-inch pots of unsterilized compost the soil was treated by adding to each an inoculum composed of equal quantities of a suspension of Verticillium and the antagonistic organism. The seedlings were then set out and observations made on the dates of appearance of the disease. Twenty-six different organisms were used in the experiment, 17 of which were fungi and 9 bacteria, and 4 plants were inoculated with each organism. At the completion of the experiment after ten weeks, four organisms showed control to the extent of 25%, while the inoculated checks showed 100%, and the controls 77% infected plants.

An experiment similar to the one described above was carried out by using seed instead of young plants in the pots but there was such a variation in the percentage of germination which might have been due to infection by the pathogen at an early date, that it was impossible to determine the accurate percentage of the disease present.

The results obtained from these experiments at least suggest that by the utilization of an improved technique some measure of biologic control may be obtained.

## Control Recommendations

1. Obtain seed from disease-free plantations.
2. Sterilize seed before it is planted.
3. Grow all plants in sterilized soil from the time the seed is planted until it is set out in the field.

4. Do not plant eggplants in locations where Verticillium susceptible hosts such as raspberries, tomatoes, potatoes, etc., have been grown, without a lapse of several years, but have them follow some cereal, grass or green manure crop.

5. Remove all Verticillium susceptible hosts including tomatoes and potatoes as well as eggplants from the field and burn them before the ground is ploughed because the amount of the pathogen in the soil will be increased by turning under refuse from a diseased crop.

6. Never throw diseased plants on the manure or compost pile as this is an ideal method of contaminating an entire farm.

7. During cultivation, care should be taken to eliminate as far as possible the transportation of soil from locations where the disease is present to those where it has not been observed.

## SUMMARY

1. Wilt of eggplants is of general occurrence and no varieties known at the present time show any appreciable resistance to the disease.

2. The symptoms of the disease have been given in detail.

3. The disease is caused by a fungus tentatively identified as *Verticillium Dahliae* Kleb.

4. The pathogen is a vascular parasite and may be isolated from all parts of the plant including the seed.

5. The definite pathogenicity of the organism has been established.

6. The organism will grow between the temperatures of 8°C and 34°C, and within the range of pH 2.3 and pH 9. Optimum growth, however, occurs between 21°C and 24°C and above pH 5.4.

7. Vascular discoloration has been observed in the roots, main and secondary stems, leaves, fruit pedicels and fruit, though it need not always show in all parts of a diseased plant.

8. The pathogen is capable of producing the typical wilt in plants at soil temperatures between 11°C and 30°C but not at 35°C.

9. The application of different fertilizers had no controlling effect on the disease.

10. The addition of a solution of mercuric chloride to the soil prior to setting out the plants, with additional subsequent applications, showed definite control under greenhouse conditions and a considerable retarding effect upon the progress of the disease in the field.

11. Applications to the soil of cultures of organisms which show an antagonistic reaction to Verticillium in vitro have not yet proved effective as a means of control.

12. Control recommendations have been suggested.

## ACKNOWLEDGEMENT

Acknowledgement is gratefully extended to Dr. G. H. Berkeley for helpful suggestions and constructive criticism rendered throughout the progress of this investigation.

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# STUDIES ON THE MALTING QUALITY OF BARLEY

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[Received for publication March 10, 1933]

## I. THE EFFECT OF LOCATION ON THE MALTING QUALITY OF BARLEY[2]

In Europe, particularly in England and Germany, the maltsters have the land zoned into districts according to the quality of the malting barley that is produced. In Canada the zoning of the country has never been publicly undertaken although certain malting organizations in Western Canada select their barley by the carload, and no doubt location is a factor in making their selection.

When the Manitoba Barley Research Laboratory was organized by the Manitoba Department of Agriculture at the Agricultural College, the study of the effect of location on the malting quality of barley was one of the first investigations undertaken by the Agronomy Department.

The object was to determine the areas in Canada, and particularly in Manitoba, best suited for the production of barley to fulfill the requirements of the Canadian maltsters. The barley was grown by the Dominion Experimental Farms under the direction of Mr. L. H. Newman, Dominion Cerealist, by the different Universities under the direction of their plant breeders, and by individual farmers in Manitoba, under the direction of the author. The tests were made in the Barley Research Laboratory. The tests made were those outlined in a previous publication by the author (*2*).

The varieties used consisted of the standard six-row and two-row sorts, i.e. O.A.C. 21, Trebi, Hannchen, Canadian Thorpe and similar varieties.

### COMPARISON OF PROVINCES

In Prince Edward Island there was little to choose between the stations; Glenwood however, was slightly superior to Charlottetown. On the whole the barley from the Island was of remarkably high quality, of good germination and growth and high in extract.

The samples from Nova Scotia grown at Nappan, whilst of good quality, were not equal to the samples from the Island.

The Quebec samples were of excellent quality, slightly better than Nova Scotia, but not equal to Prince Edward Island. The samples from St. Anne de la Pocatière were very low in protein but the extract was not quite as high as at Cap Rouge. There was little choice therefore, between the different areas in Quebec.

The Ontario barley was somewhat inferior to the Quebec barley, being thicker in the hull, higher in protein and lower in extract. It should be noted however, that no samples were tested from the Bay of Quinte area in Ontario. The Ottawa samples were much higher in protein than either Kapuskasing or Russel. The Russel samples were fair in extract, while the Kapuskasing samples were thicker in the hull.

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[2] This investigation should be considered only a preliminary study; it has not extended over a long enough period or been complete enough in the points and varieties tested. It does however, give some indication of the areas best suited for the production of good malting barley and of the varieties best suited for the malting industry.

The Manitoba tests are about equal to Ontario with the Swan River samples distinctly superior, being low in protein, high in extract, and of good germination and growth.

The Saskatchewan samples were inferior to Manitoba; the protein is very much higher, and the extract is very much lower. Comparing the stations Kamsack is the best, Swift Current the poorest, with Indian Head and Rosthern coming in between.

In Alberta the best barley was produced in the Northern portion. In this area Beaverlodge and Fort Vermilion were low in hull but high in protein In this respect they were better than Saskatchewan but not quite equal to Manitoba. The extract was fair but not as high as in some of the other Provinces, including Manitoba and the Maritimes.

As one would expect the samples from the different sections in British Columbia are quite variable; taking the average they would be about equal to the Alberta samples. Agassiz barley was distinctly superior to that from the other stations; it was thin in the hull, low in protein and high in extract. Kamloops, on the other hand, was distinctly inferior. Vanderhoof also was poor, the barley in this case being very immature.

## Comparison of the Crop Zones in Manitoba

In Manitoba a much more detailed study was made. Plots of O.A.C. No. 21 were grown by farmers under the supervision of the author in each of the crop zones.

The Inter-Lake area as represented by Ericksdale, produced an excellent quality of barley; the protein was low, the extract high, the hull was thin and the germination excellent. The Red River Valley (Winnipeg and Morden) gave barley of good quality; it was low in protein and fair in extract. The Southern Drift area (Crystal City and Killarney) was high in protein but were fair in extract. The Souris Plain (Deleau) was even higher in protein but had a good extract. The Carberry Plains (Carberry) gave an excellent barley equal to the Inter-Lake barley, being very low in protein and high in extract. In the Central Drift (Brandon) the quality is poor, the protein is high, extract low and germination poor. The Northern Drift (Birtle) is poor, the protein is very high and the extract low, although the germination is good. In the Riding Mountain Wash (Plumas) the quality is again good. The Valley between the Riding Mountains and the Porcupine Hills (Gilbert Plains) is also good. Swan River Valley, however, produces the best quality of barley in Manitoba.

## Summary

Taking Canada as a whole, the indications are that Prince Edward Island would produce the best barley in the Dominion, and that a fair quality can be produced in the other Eastern Provinces. In British Columbia the quality is variable, depending on the soil and climatic conditions of the different valleys. On the prairies, Manitoba produces the best quality although fair quality can be grown in the Northern sections of both Saskatchewan and Alberta. In Manitoba the Eastern and Northern parts give the best results.

## II. Barley Varieties and Malting Quality

The maltster evaluates barley according to the following factors (*2*); (a) cost of preparing the barley for malting, i.e. cleaning, grading, drying, etc.; (b) ease of malting, i.e. percentage and uniformity of germination, absence from mould,etc.; (c) quantity of malt produced from a bushel of barley, i.e. plumpness, and size of kernels, thickness of hull, etc.; (d) quality of malt produced, i.e. amount of malt extract, protein content, diastatic activity, etc. In a study of the malting quality of varieties the first two factors should be given only cursory consideration because they are due primarily to environmental conditions and cultural practices. The last two however, are all important because they are due to the heriditable qualities of the variety.

The experimental study of the malting quality of barley varieties was undertaken by the author in 1925, in the Barley Research Laboratory established by the Manitoba Department of Agriculture at the Agricultural College, Winnipeg.

Previous to this the Canada Malting Company had tested varieties grown at different points in Canada and published the results in the form of annual reports (*2*). For their purpose they found O.A.C. 21 the most desirable variety. In 1925 the following varieties were grown on the agronomy field at the Agricultural College: Manchurian Group—O.A.C. No. 21, Chinese, Manchurian, Bearer; Mediterranean Group—Trebi, Barks; Duckbill Group —Canadian Thorpe. They were tested by the author and Mr. J. P. Grant, Plant Superintendent in the Canada Malting Company's malt-house in Winnipeg. The method consisted in weighing out 12 ozs. of barley, placing it in a cylindrical cage and keeping the cage covered in a regular "piece" of malting grain in the malt-house. All determinations excepting protein were made at the plant. The methods used in the later studies are those outlined by the author in a previous paper (*4*). All calculations of determinations made on the grain excepting weight per measured bushel were on a 13.5% moisture basis, while the determinations on the malt are on the dry basis.

In the first year's test the Mediterranean Group was very low in protein, uneven in growth but very nearly as good in extract as the Manchurian Group. Everything considered the Manchurian Group gave the best results.

In 1926 the varieties were again grown on the experimental field of the Agronomy Department at the Manitoba Agricultural College. Three new varieties were added to the list. Mr. P. Stewart, Secretary of the Canadian Seed Growers' Association, supplied Plumage Archer and New Sunrise of the Chevelier Group, two varieties that were being introduced with considerable success in Great Britain. Duckbill, a two-row variety that had been giving good results on the Dominion Experimental Farms, was also included in the Duckbill Group.

That year the malting was done with improvised equipment in the Agronomy Laboratory at the Manitoba Agricultural College. In this test O.A.C. No. 21 again demonstrated its superiority among the Manchurian varieties, while the Plumage Archer and New Sunrise in the Chevelier Group gave most excellent results.

In 1927, Trebi, Duckbill, Hannchen and O.A.C. No. 21, representing the four groups, were tested out at several points in the province, in an endeavor to determine if certain varieties were better suited to certain districts. In this test there was considerable variation in the varieties at the different points, but the most striking result was the excellent extract that was obtained from Hannchen at all points. O.A.C. No. 21 gave the best germination. The protein and hull was variable but the Trebi was most often lowest in protein and highest in hull. The indications are that O.A.C. No. 21 will give the best malting results in the South and the Hannchen in the North.

In 1928, considerable interest was being shown in the British malting barley market; consequently, several new Mediterranean varieties were procured by Premier John Bracken while on a business trip to California, and a few Chevelier varieties were secured by the author from the maltsters in Great Britain. These, along with the standard varieties, were grown at Winnipeg. From an agronomic standpoint the Californian varieties were very disappointing. They were badly infected with disease and gave a poor yield per acre of inferior appearing barley. The malting was done on the equipment supplied by the Manitoba Department of Agriculture (*4*).

In the Mediterranean group the Trebi gave the best results, so that from the standpoint of either a home or export malting barley market the Mediterranean group is not promising. Among the Chevelier two-row group the Hannchen, Plumage Archer and New Sunrise gave good results. For uniformity and quick germination the O.A.C. No. 21 and Chinese stood at the top of the list.

In 1929, after the author had investigated the malt barley market in the United Kingdom and on the European Continent, many new varieties were added to those tested. It was hoped that by this practice a variety better suited to the overseas trade, and at the same time suitable to Canadian agronomic conditions, might be discovered. On this test a six-row variety of the Manchurian group called "July" was introduced from Ireland. While this variety did not give particularly good agronomic results, it was distinctly the best malting barley of the group. It gave a high extract, a quick uniform growth and was low in both hull and protein. The Regal (a variety introduced by the University of Saskatchewan) gave a very good extract but was uneven in germination.

Among the Chevelier two-row group the Hannchen again stood at the top of the list in extract and germination. Spratt Archer and Plumage Archer were also near the top.

In 1928 and 1929, several of the varieties were malted according to the English method; this consisted of the long germination period such as is secured by the floor method (*3*). This was done to determine which of the varieties would be best suited for the British trade. In this test the Chevelier two-row barleys gave the highest yield of extract. In this group Hannchen and Plumage Archer stood at the top. In the six-row class the Manchurian group gave the best results, although the Mediterranean group contained several of the Californian varieties such as Bay-brewing, Mariout, Hero, etc., which are ordinarily used by the British maltsters and brewers in their various blends.

The following is a list of some of the more common varieties tested: Six-Row, Manchurian Group—O.A.C. No. 21, Chinese, Manchurian, Bearer, Keystone, July, Regal, Plant's Selection, Confort, Minsturdi, Glabron, Wisconsin No. 38, Improved Manchurian, Danubian, Velvet, Star; Six-Row Mediterranean Group—Trebi, Berks, Vaughan, Atlas, Sacremento, Hero, Coast, Tennesse Winter, Bay-Brewing, Mariout, Smyrna, Algerian; Two-Row Chevelier Group—Plumage Archer, New Sunrise, Hannchen, Norfolk Scotch, Scotch Plumage, Scotch Standwell, Swansota, Bevans' F 112, Spratt Archer, Golden Pheasant, Svalof Braze, Svalof Victory, Svalof Gold, Australian Chevelier, Charlottetown No. 80, Danish Island, German Brewing, Polish; Two-Row Duckbill Group—Canadian Thorpe, Duckbill, Archer Goldthorpe.

## SUMMARY

For the Canadian method of malting the Manchurian group of six-row barleys gave the best results. In this group the O.A.C. No. 21 and Chinese gave considerably better returns. The July, if it were a better agronomic barley, would have a place if grown in quantity. It would have to be grown in quantity, for having a white aleurone it could not be mixed with O.A.C. No. 21 or Chinese. The Mediterranean group was unsatisfactory although it included such renowned Californian varieties as Bay-Brewing, Mariout, etc.

Among the two-row sorts the Chevelier group is distinctly superior to the Duckbill group. In this group the better varieties are Hannchen and Plumage Archer.

Under the floor method of malting such as is used in the United Kingdom, the same varieties gave the best results, namely, Hannchen and Plumage Archer among the two-row sorts, and O.A.C. No. 21 and Chinese among the six-row sorts.

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# THE ANTIRACHITIC VALUE OF PILCHARD OIL (SARDINE OIL) FOR GROWING CHICKS

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[Received for publication August 4, 1933]

In previous papers from this laboratory, Asmundson, Allardyce and Biely (*1*) and Asmundson and Allardyce (*2*) reported on the value of pilchard oil (*Sardinia cerulea*) or as it is known in California, sardine oil, as a source of Vitamin D. The literature has been already reviewed in the above papers. The purpose of the present paper is to report additional data on the antirachitic potency of various samples of pilchard oil produced in British Columbia.

## MATERIAL AND METHODS

The properties of the pilchard oils and cod liver oils used in the following experiments are shown in Table 1. It will be seen that the pilchard oils were low in free fatty acids, ranging from 0.33% to 0.91%. Furthermore, the more refined oil was lower in free fatty acid than the ordinary commercial run of pilchard oil. Our data in this respect agree with those of Gutteridge (4), who reported that the free fatty acid contents of carefully prepared samples of pilchard oil and ordinary commercial pilchard oil were .60 and .89% respectively. In this connection it should be noted that Drummond (*3*) states that free acidity greater than 1.3% is undesirable in a feed oil.

The two medicinal cod liver oils used in these experiments were significantly lower in free fatty acid (.16 and .54% respectively) than the commercial cod liver oils used by Gutteridge (*4*), i.e., 2.16 and 3.69% respectively.

TABLE 1.—COMPARISON OF THE PILCHARD OILS AND COD LIVER OILS USED IN EXPERIMENTS 1 AND 2.

| Oil | Lot | Free fatty acids as oleic Percentage | Lovibond blue units in 10% solution Percentage | Remarks |
|---|---|---|---|---|
| Pilchard oil | 1 | 0.64 | 2.1 | Ordinary commercial run of oil produced in August, 1932. Clear amber in colour. Kept in steel tanks containing 10,000 gallons. Sample drawn 1 foot below surface of oil. |
| Pilchard oil | 2 | 0.91 | 2.4 | Ordinary commercial run of oil produced in August, 1931. Clear amber in colour. Kept in steel tanks containing 10,000 gallons. Sample drawn 1 foot below surface of oil. |
| Pilchard oil | 3 | 0.33 | 0.6 | Special sample of oil produced in August 1932, by the same steaming process as used for tendering cod livers. Light straw color. Kept in 4-gallon tin container. |
| Cod liver oil (E) | 4 | 0.16 | 5.0 | Medicinal cod liver oil (E). Bottled. |
| Cod liver oil (A) | 5 | 0.54 | 7.2 | Mecicinal cod liver oil (A). Bottled. |

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In respect to the free fatty acid, it seems that the commercially produced pilchard oils compare favorably with medicinal cod liver oil.

The chicks used in these experiments (S.C.W. Leghorn and various cross-breds) were raised in battery brooders containing warm and cool compartments. The chicks were divided according to ancestry as evenly as possible into the respective lots. Mash and water were kept before the chicks all the time.

## EXPERIMENTAL

### *Experiment 1* (Oct. 4, 1932)

A ration recommended by Hart, Kline and Keenan (*6*) was fed to the experimental chicks. The basal ration was mixed every two weeks with the various oils as follows:

Lot 1—1% pilchard oil produced in 1932.
Lot 2—control.
Lot 3—1% pilchard oil produced in 1931.
Lot 4—1% carefully refined pilchard oil produced in 1932.
Lot 5—1% medicinal cod liver oil. (A)

At six weeks of age five chicks (3 males and 2 females) from each of Lots 1, 3 and 4, and six chicks (3 males and 3 females) from each of Lots 2 and 5 were killed. The tibia and fibula of each chick were analyzed for ash by the method described by Hart *et al* (*6*). The data for the different lots are summarized in Table 2. With the exception of the control chicks, which showed rickets, the chicks in all lots appeared to be normal. It will be seen that mortality in all of the lots was low, and with the exception of the control lot, the average weights of the chicks were satisfactory. The ash analyses show that the pilchard oils used were equal in value to medicinal cod liver oil in promoting normal bone calcification.

TABLE 2.—EXPERIMENT 1. COMPARISON OF WEIGHTS OF CHICKS RECEIVING 1% OF PILCHARD AND COD LIVER OIL AND ASH ANALYSIS OF TIBIA AND FIBULA

| Lot No. | Oil fed* | No of chicks started | No. of chicks alive at 6 weeks of age | Average weight of chicks at 6 weeks of age grams | Average weight of 5 chicks killed for ash analysis: grams | Average per cent of ash in tibia and fibula of 5 chicks |
|---|---|---|---|---|---|---|
| 1 | Pilchard No. 1 | 20 | 17 | 318.5 | 358.0 | 42.04 |
| 2 | Control | 20 | 18 | 266.6 | 252.1† | 33.25 |
| 3 | Pilchard No. 2 | 20 | 19 | 333.7 | 358.2 | 41.64 |
| 4 | Pilchard No. 3 | 20 | 18 | 321.5 | 328.0 | 42.45 |
| 5 | Cod liver oil (A) | 20 | 18 | 330.8 | 334.8† | 43.37 |

* See Table 1.
† Note: 6 chicks.

### *Experiment 2* (Feb. 10, 1933)

For the second experiment the basal ration recommended by Gutteridge (*4*) was used. This ration is made up of ingredients usually employed in the preparation of commercial poultry mashes: shorts, middlings, yellow corn-meal and ground oat groats—22% of each; meat meal—6%; fish meal, buttermilk powder and bone meal—2% of each; oyster shell. Since it was not convenient to feed the latter separately, 1% of finely ground oyster shell was incorporated in the mash. The basal ration was supplemented as follows:

Lot 1—1% medicinal cod liver oil (E).
Lot 2—½% pilchard oil.
Lot 3—1% pilchard oil.
Lot 4—control.

At six weeks of age five chicks (3 males and 2 females) were killed and analyzed for bone ash. The data are summarized in Table 3. With the exception of the control chicks the chicks in all lots grew at a very uniform rate. The chicks receiving pilchard oil and cod liver oil showed normal ash contents, while in the control chicks the percentage of ash was the lowest amongst the four lots.

TABLE 3.- EXPERIMENT 2.—COMPARISON OF WEIGHTS OF CHICKS RECEIVING PILCHARD OIL AND COD LIVER OIL AND ASH ANALYSIS OF TIBIA AND FIBULA.

| Lot No. | Oil fed* | Per centage of oil fed | No. of chicks started | No. of chicks alive at 6 weeks of age | Average wt. of chicks at 6 weeks of age grams | Average wt. of 5 chicks killed for ash analysis—grams | Average per cent of ash in tibia and fibula of 5 chicks |
|---|---|---|---|---|---|---|---|
| 1 | Cod liver oil (E) | 1 | 14 | 14 | 361.4 | 320.8 | 43.53 |
| 2 | Pilchard No. 3 | .5 | 13 | 13 | 366.0 | 317.6 | 42.11 |
| 3 | Pilchard No. 3 | 1 | 13 | 12† | 389.3 | 383.2 | 43.65 |
| 4 | Control | None | 14 | 14 | 267.4 | 265.0‡ | 33.21‡ |

Note: * See Table 1.
† Chick killed—slipped tendon.
‡ 8 chicks.

## Discussion

The results obtained in these experiments agree with those of previous investigators, that pilchard oil is equal to medicinal or commercial cod liver oil in promoting normal bone development. The data further indicate that chicks receiving ½% of pilchard oil showed normal growth and bone development comparable to that of chicks receiving 1% medicinal cod liver oil. Whether smaller doses than ½% would be sufficient to prevent rickets is a matter for further trials. It is quite apparent from these experiments that the ordinary run of commercial poultry pilchard oil is equal in Vitamin D value to the carefully refined pilchard oils. It is also apparent that pilchard oils stored for a year or more under proper conditions do not deteriorate in quality. The results obtained by Asmundson and Allardyce (*2*), by Gutteridge (*4*), and by ourselves, seem to indicate that the pilchard oils produced in British Columbia are a good source of Vitamin D.

Gutteridge (*5*) has recently shown that pilchard oil is also a source of Vitamin A. Although the colorimetric test (Lovibond blue units) is not an exact criterion of the Vitamin A contents of pilchard oil, it is interesting to note that the pilchard oil used by Gutteridge in his Vitamin A studies contained 2.20 Lovibond units, which equals the number of Lovibond units contained in samples 1 and 2 of this series. It should be noted, however, that samples 3, Table 1, showed the lowest colorimetric rating. This oil (sample 3) was prepared from a specially light colored pilchard oil.

A comparison of the two cod liver oils shows that, when fed at a 1% level, they are equally potent in antirachitic properties. However, as judged by the colorimetric test, these oils show a difference in Vitamin A contents. Thus "E" oil contained 5 Lovibond units as compared with 7.2 Lovibond units in the "A" oil. Since a colour value of less than 5 Lovibond units indicates an oil of low Vitamin A potency, it would appear that the "E" oil is not a good source of Vitamin A, while the "A" cod liver oil slightly exceeds the minimum limit of 7 units stated by Drummond (*3*) to be desirable. The low Vitamin A contents of the two cod liver oils, as judged by the colorimetric test, is quite surprising in view of the fact that both oils were biologically tested to ensure a high concentration of the fat-soluble Vitamins A and D. It is obvious, therefore, that the various oils used both in the feeding of livestock and of children need to be carefully standardized before they are placed on the market.

## SUMMARY

Chicks fed a basal ration, lacking Vitamin D, which was supplemented with commercial pilchard oil at ½% and 1% levels, showed practically the same ash analysis as chicks fed similar rations which were supplemented with 1% of the medicinal cod liver oils.

## ACKNOWLEDGMENT

The writers wish to express their great indebtedness to Mr. F. D. Mathers, who supplied the various pilchard oils for experimental purposes. The acidity test and colorimetric assay were made through the courtesy of Dr. F. T. Shutt, Dominion Chemist.

## ADDENDUM

In conjunction with Experiment 1, one lot of chicks (12 chicks) was exposed at a distance of 10 inches to two 60-watt CX Mazda lamps in the warm compartment of the battery brooder. These lamps, together with one carbon lamp, acted also as a source of heat, and therefore were in use twenty-four hours daily. Since the chicks spent part of the time in the cool compartment, they were probably not exposed to the ultra-violet rays of the CX Mazda lamps for more than 12 to 14 hours a day.

At the end of six weeks the chicks weighed 327.6 grams, or practically the same as the chicks in Experiment 1. The average weight and the average ash contents of the tibia and fibula of the five chicks which were analyzed were 325.4 grams and 42.55 per cent respectively. Since the average ash analysis of the irradiated chicks was nearly the same as the average ash analysis of the chicks receiving pilchard or cod liver oil, it is concluded that in this trial the CX Mazda lamp was a satisfactory source of Vitamin D. This is in agreement with the data of Miller, Bearse and Cushing (Poultry Science, Vol. 12, No. 1, pp. 21-22, 1933), who report that chicks exposed over 7 hours a day at a distance of 10 inches to CX Mazda lamps showed normal bone calcification.

The authors are greatly indebted to Mr. S. J. Bowman, Agricultural Representative of the B. C. Electric Railway Company Limited, Vancouver, B.C., for the installation and use of the CX Mazda lamps.

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# CURRENT PUBLICATIONS

## THE EFFECT OF WINTER EXPOSURE IN THE STOOK ON QUALITY OF WHEAT. R. K. Larmour, J. G. Malloch and W. F. Geddes. Canadian Journal of Research *9:* 252-260.

Samples of wheat were exposed in the stook over winter and threshed in the spring in two seasons. These spring-threshed samples were compared with check samples from the same lots that had been threshed in the fall. The exposed samples lost grade in 50% of the cases, and decreased in weight per bushel in practically all cases. The flour yield was generally increased slightly as a result of the winter exposure. In respect to baking quality 22% showed improvement and 40% showed damage. The changes in grade and bushel weight do not correspond very closely with changes in baking behaviour.

# ELECTROLYSIS OF SEED OF CEREALS

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[Received for publication September 14, 1933]

## INTRODUCTION

For a number of years there has been available a group of patented processes for the treatment of seeds prior to sowing, known collectively as the "Wolfryn Electro-chemical Process". A fairly wide range of treatments is described in patents covering this process, associated with the names of C. E. DeWolf and H. E. Fry. In certain cases soaking the seeds in various solutions was stated to increase their productivity; in other descriptions, electrolysis was called for. Various subsequent treatments are described such as sprinkling the seed with petroleum, lime, etc., after which it is sown in the customary manner.

The process has been stated to increase the yield per acre, to increase resistance to inimical bacteria, and to produce seed of better quality. Should these claims prove to be sound, the importance of the process to an agricultural country is obvious, hence it seemed worthy of careful examination. This paper describes the laboratory and field tests carried out on the Wolfryn process. The electrochemical treatment was given at the National Research Laboratories, Division of Chemistry, while the field tests were carried out by the Dominion Experimental Farms, Cereal Division, and by the Federal Branch Farms at Fredericton, N.B., and Charlottetown, P.E.I.

## PART I. DESCRIPTION OF PROCESS AND EXPERIMENTAL TREATMENTS

L. M. PIDGEON

### THE PROCESS AS DESCRIBED IN PATENTS

Before discussing the methods employed in the present research it is of interest to review some of the descriptions of the process which have appeared in the patent literature.

Canadian patent 156241 taken out in 1914 by C. E. DeWolf describes the improvement of seeds by placing them in a solution of manure through which an electric current is passed. The seeds may subsequently be sprayed with petroleum or benzine.

A later patent, Canadian 179503, taken out in 1917 to C. E. DeWolf and H. E. Fry claims to improve the seed by steeping in radioactive water. The time of steeping depends on the seed, being 24 hours for wheat, 36 hours for barley and oats, and 48 hours for maize. These times may be shortened to 3, 4, and 5 hours respectively by passing a current between electrodes fixed at each end of the bath, (that is, the electrolysis is purely incidental and the essential part of the treatment may exist without it.) If the water is not naturally radioactive, it is made so by exposing it to emanation. This patent also includes steeping the seeds in a solution of manure and radioactive water. After any of these treatments the seed is dried and may be sprinkled with petroleum or benzine. A number of permutations and combinations of the above are included in the patent.

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British patent 102081, 1916 to DeWolf and Fry is essentially similar to that described above in that electrolysis is incidental. "According to this invention the seeds are steeped before they are sown in natural mineral waters similar to those which are used for therapeutic purposes, and which contain solutions of nitrogen, chlorine, and other gases and small quantities of metallic salts, after which the seeds are sown as promptly as possible." Electrolysis is mentioned as shortening the time of steeping. Radioactivity is not mentioned.

The essential point of these various methods is the soaking of the seed in certain solutions prior to sowing; electrolysis in most cases is mentioned as an accessory. However when we examine the work which has been done previously on the subject, together with later specifications it appears that electrolysis is the essential feature and the solution may be ordinary saline (NaCl).

An enthusiastic and very popular account of the process is given in "A Manual of the Electrochemical Treatment of Seeds" by Charles Mercier M.D. (University of London Press 1919). In this account electrolysis is represented as being the important factor; soaking is effective but to a lesser degree. The process calls for immersion of the seed in 2% to 5% sodium chloride solution through which a current is passed between iron electrodes. After electrolysis the seed is drained and dried at 100° F. No subsequent treatments are described but immediate sowing is recommended.

The author admits the lack of quantitative data on the merits of the process but states that very favorable reports were obtained from the 150 farmers who employed the treatment in 1918.

The electrical units given in the text and other remarks of the author exhibit a failure to appreciate the significance of the laws of electrolysis. The term "electrification" is used for electrolysis throughout. The possible reactions at the electrodes are not discussed, nor does the author appear to be aware of their existence, except perhaps in one place where he mentions that iron electrodes produce better results than carbon. It is obvious that a different chemical solution is produced by these procedures containing ions of very different character, so that one would expect differences in behaviour. This matter will receive further discussion below.

## PREVIOUS INVESTIGATIONS OF THE PROCESS

Dr. E. J. Russell[1], director of the Rothamsted experimental station has described a number of experiments carried out at Rothamsted and elsewhere in England during 1918-1919. The treatment used in these experiments followed details given in the "Manual of Electrochemical Treatment of Seeds" described above. The seeds are placed in a 2-5% sodium chloride solution through which a current is passed between iron electrodes. After treatment the seed was dried at 100°F. The subsequent examination was by means of pot culture. Treated and untreated seed was planted in pots both manured and unmanured. The results may be briefly summarized as follows.

Out of 14 measurements made in 1919, four were in favour of the process, eight were unfavourable. Two months had elapsed between treatment and sowing in this case and to remove this possible objection, the experiments were repeated at Oxford under circumstances where but one month elapsed. The results in this case were more favorable but no definite trend was noticeable. (In the experiments to be described in this paper the sowing took place within 4 to 7 days of treatment.) Measured field tests were mentioned, carried out at South Eastern Agricultural College, Wye. In these tests no difference could be detected between the treated and untreated seed. A number of farm tests were mentioned, some of which appeared to be successful; however, as in most cases no precautions were taken to ensure accurate collection of data, and as only a fraction of the farmers reported at all, the author does not place much reliance on these trials. Based on his own experiments and those of others, the author classified the process among those which are occasionally successful but are greatly inferior to manuring which is almost invariably successful in increasing the yield.

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[1] E. J. Russell, Journal of the Ministry of Agriculture, Vol. XXVI, p. 971. 1920.

## EXPERIMENTAL WORK

The seed treatment which has been followed in this work is based on details supplied by A. W. DeWolf, of Montreal, and which are assumed to represent the preferred practice of the inventors. It is completely an electrochemical process, i.e. there is no mention of therapeutic, or radioactive waters. The importance of current density during electrolysis is appreciated and sufficient details are given for an accurately controlled process. The description is summarized below.

## WOLFRYN ELECTROCHEMICAL PROCESS

1. The grain is to be placed on rectangular tanks of wood or brick of the following general dimensions: 8 ft. by 4 ft. by 2½ ft. The ends of the tank are covered by iron plates of ⅛ inch thickness which act as electrodes. (Any suitable container is stated to be satisfactory for small tests.)

2. A 2½% solution of sodium chloride is added. The grain is to be covered by the solution; 5 gallons of solution per bushel of grain is recommended. The seed is allowed to soak for two hours in this solution being turned over occasionally.

3. A direct current is passed between the electrodes; 2 amperes per square foot of the active surface of one of the electrodes is called for. The following times are required by various seeds:

| | | |
|---|---|---|
| Wheat and Rye ...... | 3½ hours | The seed is to be stirred occasionally during electrolysis. |
| Oats . ... | 4½ " | |
| Barley and Maize ... | 7 " | |

4. The grain is left to soak in the resulting solution for about 16 hours.

5. The solution is then run off until the seed is well drained, after which it is removed from the tank and spread upon a floor until excessive moisture has disappeared. (The depth of the grain should not exceed 4 to 6 inches.)

6. The seed is sprinkled with slaked lime, as fine as flour, until the whole is coated with the lime. It will be ready for sowing in about 24 hours, but may be kept on the floor without detriment for some weeks provided it is turned over occasionally.

It was decided to restrict the trial to wheat only, and to attempt to examine the significant features of the process. These are briefly:

1. Soaking in NaCl solution.
2. Electrolysis between iron electrodes.
3. Sprinkling with lime.

In view of the fact that the use of iron electrodes in a sodium chloride solution produces iron chloride in solution during electrolysis, it was decided to examine an additional replicate employing carbon electrodes.

The sample of Huron wheat obtained from the Central Experimental Farm was accordingly divided into five lots which are designated A, B, C, D, and E throughout.

*Details of Treatment.*—Glass battery jars 9 inches by 5⅛ inches by 5⅛ inches were employed as containers. Clean iron electrodes were placed in the ends of A and B. Graphite electrodes were used in the case of C. The seeds were stirred from time to time with wooden paddles.

The three electrolytic cells were connected in series and direct current passed from a full-wave valve rectifier operating on 110 volts 60 cycle. A current of 110 milliamperes was passed through the solutions, which conforms to the current density called for in the description given above.

The actual treatment received by each sample was as follows:

A. 1. Soaked in 2½% NaCl solution for 2 hours.
   2. Current passed between iron electrodes (14 milliamps. per sq. inch. of electrode) for 3½ hours.
   3. Soaked in same solution for 16 hours.
   4. Dried on a flat surface at room temperature for 24 hours.

B. 1. Soaked in 2½% NaCl solution for 2 hours.
   2. Current passed between iron electrodes for 3½ hours. (14 milliamps. per sq. inch of electrode surface).
   3. Soaked in the resulting solution for 16 hours.
   4. Dried as above for 24 hours.
   5. Sprinkled with fine lime.

C. 1. Soaked in 2½% NaCl solution for 2 hours.
   2. Current passed between graphite electrodes for 3½ hours. current density as above.
   3. Soaked in the resulting solution for 16 hours.
   4. Dried as above for 24 hours.
   5. Sprinkled with fine lime.

D. 1. Soaked in 2½% NaCl solution for 21½ hours.

E. Untreated, for control.

*Discussion of Treatment.*—Samples A and B have received treatments which conform as nearly as possible to the description which was supplied by A. W. DeWolf, except that in the case of A the lime treatment has been omitted. It is obvious that with iron electrodes in NaCl, a direct current will produce solution of the iron at the anode. Ferric or ferrous chloride will be produced depending on the current density, in the present case probably the latter. Caustic soda is produced at the cathode. This solution of iron caused a darkening of the electrolyte and caused the seeds to lose their yellow colour and assume a green-grey colour.

In the case of sample C inert electrodes were employed. In this case chlorine was produced at the anode and NaOH at the cathode. The mechanical stirring resulted in considerable mixture, hence in this case the treatment was practically equivalent to soaking in sodium hypochlorite solution. No bleaching was noticeable; the seeds appeared unchanged after the treatment.

Sample D was soaked in sodium chloride solution of the same strength as that employed for the electrolysis and for the same time. This procedure was followed in an endeavor to separate the effect of electrolysis and of soaking in a chemical solution.

It will be seen from the results to be described in the second part of this paper that all of these treatments gave lower yields than the untreated seed and that no significant difference was obtained between A and B; hence in this case the lime sprinkling had no effect. Sample C in general was inferior to the other treated samples, hence the sodium hypochlorite has a detrimental effect in this case. Sample D which was soaked without electrolysis gave results very similar to A and B. Hence no advantage has been gained by any treatment. This is in agreement with the results of the Rothamsted experiments.

## PART II. GERMINATION AND FIELD TRIALS

J. G. C. FRASER

### METHODS

For field trials the seed used was wheat of the Huron Ottawa 3 variety, Elite stock being secured by the Cereal Division and this carefully graded over a screen having round perforations 8/64 inch. in diameter. A total of eight pounds was prepared as above and this material was sent to the National Research Council for treatment prior to seeding, the Cereal Division not being equipped to provide the particular treatment involved.

Following the treatment of the seed, it was sent to the Cereal Division, Ottawa, the Experimental Station at Fredericton, N.B., and the Experimental Station at Charlottetown, P.E.I., for yield tests.

### FIELD TESTS BY CEREAL DIVISION, OTTAWA

The treated seed was received from the Research Council on May 14th, 1932, and consisted of five lots, designated A, B, C, D and E. The first four lots were treated in different ways, outlined in Part I, the fifth lot being left untreated as a check or "control". In addition to these lots, it was thought advisable to include another lot taken from the same original bulk lot and which had been immersed in water at 16° C (70°F) for eight hours, but which had received no other treatment. This sixth lot was designated F. The plots devoted to the test were located on well prepared land of reasonably uniform quality. Seeding took place at Ottawa on May 17th, 1932, and harvesting on August 25th.

*Germination.*—Careful counts were made of the number of plants produced in all plots in order to avoid possible errors due to differences in stand. In Table I will be found the actual number of plants produced, together with the mean for the four plantings in the case of each lot.

TABLE 1.—FIELD GERMINATION COUNTS

| | A | B | C | D | E (untreated) | F (soaked only) |
|---|---|---|---|---|---|---|
| Rep. I | 283 | 260 | 244 | 262 | 361 | 310 |
| Rep. II | 263 | 274 | 238 | 239 | 328 | 309 |
| Rep. III | 244 | 237 | 245 | 247 | 338 | 324 |
| Rep. IV | 262 | 271 | 244 | 270 | 333 | 391 |
| Mean | 263 | 260 | 242 | 254 | 340 | 333 |

*Tillering.*—Among other field observations, the nature of tillering or "stooling" was noted. This was recorded as uniform for all plots. In the early part of July there appeared areas in the first three replicates which gave evidence of stunted growth. In order to evaluate the magnitide of variation or error produced owing to this peculiarity the probable error was calculated. The following figures illustrate the P.E. in per cent of the yield, 1000 kernel weight, and length of straw for the B plots for the four replicates, as well as the unaffected plots.

TABLE 2

| | | | Difference |
|---|---|---|---|
| P. E. of yield for unaffected plots | = | ± 5.41 | ± 4.11 |
| P. E. of yield for all plots | = | ± 9 52 | |
| P. E. of 1000 kernell wt. for unaffected plots | = | ± 2 97 | ± 13 |
| P. E. of 1000 kernell wt. for all plots | = | ± 2 84 | |
| P. E. of length of straw for unaffected plots | = | ± 6 06 | ± 4.01 |
| P. E. of length of straw for all plots | = | ± 2.05 | |

It so happened that one of each treated and check plot had affected areas. Possibly B was most seriously damaged, consequently it was deemed advisable to make a correction by multiplying the difference in the probable error by the yield of each B plot. (Hayes and Garber method).

TABLE 3.—COMPARATIVE YIELDS IN LBS PER ACRE

| | B's P. E. correction | B. not corrected | Checks | |
|---|---|---|---|---|
| | | | E (Dry) | F (Wet) |
| Rep. I | 1605.3 | 1542 0 | 1985.8 | 1909.6 |
| Rep. II | 2410.9 | 2315.8 | 2558.1 | 2040.8 |
| Rep. III | 2047.9 | 1967.1 | 2268.0 | 2354.3 |
| Rep. IV | 2078.6 | 1996.6 | 2353.3 | 2051.6 |

The entire experiment ripened uniformly and took approximately 100 days to mature. In Tables 4, 5, 6 and 7 are given the yields in lbs. per acre presented according to Stations—Ottawa, Fredericton and Charlottetown. The data have been analysed statistically using Fisher's variance method and the results obtained are given in Table 8.

TABLE 4.—YIELDS IN LBS. PER ACRE.—OTTAWA

| | A | B | C | D | E (Dry) | F (Wet) |
|---|---|---|---|---|---|---|
| Rep. I | 1861.0 | 1542.0 | 1672.1 | 1600.0 | 1985.8 | 1909.6 |
| Rep. II | 1897.5 | 2315.8 | 1977.5 | 2455.8 | 2558.1 | 2040.8 |
| Rep. III | 2061.8 | 1967.1 | 2080.0 | 2078.6 | 2268.0 | 2354.3 |
| Rep. IV | 2308.0 | 1996.6 | 2048.6 | 1782.0 | 2353.3 | 2051.6 |
| Mean | 2032.0 | 1954.3 | 1669.5 | 1979.1 | 2291.3 | 2089.0 |

TABLE 5.—YIELDS IN LBS. PER ACRE.—FREDERICTON

| | A | B | C | D | E (Dry) | F (Wet) |
|---|---|---|---|---|---|---|
| Rep. I | 1683.3 | 2099.0 | 1681.3 | 1825.0 | 2015.3 | 1828.6 |
| Rep. II | 1752.3 | 1890.3 | 1689.3 | 1638.3 | 1730.0 | 1468.0 |
| Rep. III | 1959.0 | 1951.0 | 1556.0 | 1476.0 | 2132.0 | 1842.0 |
| Rep. IV | 1966.0 | 1871.6 | 1871.0 | 1855.0 | 2192.3 | 2206.3 |
| Mean | 1840.1 | 1952.9 | 1679.8 | 1698.5 | 2017.4 | 1836.2 |

TABLE 6.—YIELDS IN LBS. PER ACRE.—CHARLOTTETOWN

| | A | B | C | D | E (Dry) | F (Wet) |
|---|---|---|---|---|---|---|
| Rep. I | 1196.0 | 1144.3 | 1190.6 | 1150.0 | 1092.3 | 964.0 |
| Rep. II | 839.0 | 796.6 | 996.0 | 1099.0 | 1153.3 | 1100.0 |
| Rep. III | 1233.3 | 1276.6 | 1141.0 | 966.6 | 1343.0 | 1226.3 |
| Rep. IV | 1070.6 | 1141.0 | 1326.0 | 1294.6 | 1416.3 | 1254.6 |
| Mean | 1084.7 | 1089.6 | 1163.4 | 1127.5 | 1228.0 | 1136.2 |

TABLE 7.—MEAN YIELDS IN LBS. PER ACRE TEST AS OBTAINED FROM THE THREE EXPERIMENTAL STATIONS

| | Treatments | | | | | |
|---|---|---|---|---|---|---|
| | A | B | C | D | E (Dry) | F (Wet) |
| Yields in lbs. per acre | 1652.2 | 1665.6 | 1504.2 | 1601.7 | 1845.5 | 1687.1 |

TABLE 8.—VARIANCE ANALYSIS OF THE FOREGOING DATA

| Source of Variance | Sum of squares | Degrees of freedom | Variance | ½ log | Z | Fisher's 5% point |
|---|---|---|---|---|---|---|
| 1. Differences between districts | 2986.94 | 2 | 1493.47 | 3.6543 | 2.5481 | 6008 |
| 2. Differences between treatments | 144.17 | 5 | 28.83 | 1.6807 | .5745 | .4668 |
| 3. Interaction (Districts) Treatments | 61.16 | 10 | 6.11 | .9049 | −.2013 | + Ve. = .3487<br>— Ve. = .4764 |
| Error | 494.07 | 54 | 9.14 | 1.1062 | | |
| Total | 3686.34 | 71 | 51.92 | | | |

## INTERPRETATION OF TABLES

*1. Difference between districts.*—Between the districts there is highly significant variance in the total yields as Fisher's 5% point Z value is only .6008 and our calculated Z value is 2.5481. However, this should not be attributed to the treatments, but rather to the difference in suitability of varieties for various Stations and under different climatic conditions for a given year.

*2. Difference between treatments.*—According to the values obtained there is statistically no advantage gained by any method of treatment. The slightly higher obtained Z value in our experiment is apparently due to the untreated check as borne out in all foregoing tables.

*3. Interaction.*—Error variance is greater than the interaction variance, therefore, proving to be of no significance. Fisher's 5% point for + Ve. Z value = .3487, and for the -Ve. = .4764. The observed difference is really very moderate and quite insignificant.

## CONCLUSIONS

Additional data could be given to illustrate that the Wolfryn Electrochemical Process apparently has no beneficial effect on the yield of wheat, but since the actual pounds per acre are the only real index whereby to measure any economic increase, we therefore, refrain from presenting data of comparative insignificance.

While the data are only obtained from one year's results, the fact that at all three widely separated test stations the results are similar leads one to believe that there does not appear to be any advantage in employing this test as a means of increasing the yield of this variety of wheat.

## ACKNOWLEDGEMENT

For the statistical work involved in the foregoing tables having to do with yields, I am indebted to Mr. F. Gfeller, graduate student in the Cereal Division, Ottawa.

# THE ECONOMIC SITUATION

### PREPARED IN THE AGRICULTURAL ECONOMICS BRANCH, DEPARTMENT OF AGRICULTURE, OTTAWA, FROM BASIC DATA COLLECTED BY THE DOMINION BUREAU OF STATISTICS

It is frequently necessary to examine not only the short term movement of prices but also the trend over a period of months. Observations of this nature seem to be appropriate at the present time. The index number of wholesale prices receded from 69.4 in August to 68.9 in September. This index was 65.9 in September 1932; in August of last year it was 66.7. The decline in the index number in September of this year was largely due to lower prices in the vegetable products group. Textiles and textile products held even. Wood, wood products and paper advanced. Iron and its products were slightly higher. Non-ferrous metals and their products receded while non-metallic minerals and their products gained substantially. Chemicals and allied products were fractionally above the August level.

*Retail Prices.*—In the case of retail prices there was a slight advance. The August index was 78.6 whereas that for September was 78.8. Prices of food and clothing advanced whereas rentals were lower.

*Physical Volume of Business.*—The index number of physical volume of business rose from 89.8 to 90.8. The industrial production index advanced from 89.5 to 90.2. While these advances are below those reported in July and August of this year they do indicate greater business activity than was the case last year at this time when these indexes were consistently in "the seventies". During September the index of mineral production advanced from 98.0 to 108.8. Manufacturing advanced fractionally from 96.9 to 97.0. Construction showed some improvement and the index rose from 25.5 to 26.9. The forestry index declined from 94.0 to 88.0 and iron and steel production fell from 46.4 to 43.5. Agricultural marketings were lower.

*Employment.*—Employment conditions continued to improve. The number on pay rolls of firms reporting regularly to the Bureau of Statistics at October first was 834,348 as compared with 816,458 at the first of September. The index of employment thus rose to 90.4.

*Agricultural Products.*—The index number of Canadian farm products fell from 57.0 in August to 54.7 in September. Field products again registered lower prices and the index dropped from 54.9 to 49.5. Weak export demand, offerings of Russian wheat, and favourable reports of crop conditions in Southern Australia and Argentina caused wheat prices to move downward. Prices of barley and oats followed a similar course but flax and rye moved at higher quotations.

The index of animal products advanced from 60.5 to 63.4. This was largely attributed to improvement in prices of fluid milk, eggs and wool; although, on the whole, prices of hogs and claves were somewhat higher. Cattle and lambs were, however, lower.

Considering the longer period it is interesting to note that in September 1932 the index of field rpoducts was 39.5 and that of animal products 60.4. The total index of Canadian farm products in September of last year was 47.3. Carrying the comparison further it is noted that in August 1933 the index of field products was 54.9 whereas in August 1932 it was 42.3. In the case of animal products the index for August 1933 was 60.5 as compared with 58.5 in the same month last year. The total index for August 1932 was 48.4; moreover if we compare the index of July of this year with that of July 1932 it is observed that the indexes of field products were 60.8 and 42.6 respectively, those for animal products 59.0 and 57.8 and the total indexes 60.1 and 48.3.

## ANNUAL AND MONTHLY INDEX NUMBERS OF PRICES AND PRODUCTION COMPUTED BY DOMINION BUREAU OF STATISTICS

| Year | Wholesale Prices 1926 = 100 | | | | Retail prices and cost of services (5) | Production (6) 1926 = 100 | | | |
|---|---|---|---|---|---|---|---|---|---|
| | All commodities (1) | Farm products (2) | Field products (3) | Animal products (4) | | Physical volume of business | Industrial production | Agricultural marketings | Cold Storage holdings |
| 1913 | 64.0 | 62.6 | 56.4 | 77.0 | 65.4 | | | | .. |
| 1914 | 65.5 | 69.2 | 64.9 | 79.0 | 66.0 | | | .. | .. |
| 1915 | 70.4 | 77.7 | 76.9 | 79.2 | 67.3 | | | . .. | |
| 1916 | 84.3 | 89.7 | 88.4 | 92.3 | 72.5 | | | .. | |
| 1917 | 114.3 | 130.0 | 134.3 | 119.6 | 85.6 | | | | |
| 1918 | 127.4 | 132.9 | 132.0 | 134.7 | 97.4 | | | .. | .. |
| 1919 | 134.0 | 145.5 | 142.4 | 152.5 | 107.2 | 71.3 | 65.5 | 48.1 | 47.1 |
| 1920 | 155.9 | 161.6 | 166.5 | 149.9 | 124.2 | 75.0 | 69.9 | 52.6 | 94.2 |
| 1921 | 110.0 | 102.8 | 100.3 | 108.5 | 109.2 | 66.5 | 60.4 | 65.2 | 86.4 |
| 1922 | 97.3 | 86.7 | 81.3 | 99.1 | 100.0 | 79.1 | 76.9 | 82.6 | 82.6 |
| 1923 | 98.0 | 79.8 | 73.3 | 95.1 | 100.0 | 85.5 | 83.8 | 91.4 | 87.8 |
| 1924 | 99.4 | 87.0 | 82.6 | 97.2 | 98.0 | 84.6 | 82.4 | 102.5 | 114.6 |
| 1925 | 102.6 | 100.4 | 98.1 | 105.7 | 99.3 | 90.9 | 89.7 | 97.2 | 108.9 |
| 1926 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| 1927 | 97.7 | 102.1 | 99.9 | 105.7 | 98.4 | 106.1 | 105.6 | 103.6 | 110.0 |
| 1928 | 96.4 | 100.7 | 92.6 | 114.3 | 98.9 | 117.3 | 117.8 | 146.7 | 112.8 |
| 1929 | 95.6 | 100.8 | 93.8 | 112.5 | 99.9 | 125.5 | 127.4 | 101.1 | 109.6 |
| 1930... | 86.6 | 82.3 | 70.0 | 102.9 | 99.2 | 109.5 | 108.0 | 103.0 | 128.4 |
| 1931 | 72.2 | 56.3 | 43.6 | 77.6 | 89.6 | 93.5 | 90.4 | 99.0 | 125.7 |
| 1932 | 66.7 | 48.4 | 41.1 | 60.7 | 81.4 | 78.7 | 74.0 | 114.3 | 120.1 |
| 1933 | | | | | | | | | |
| Jan.... | 63.9 | 43.6 | 35.1 | 57.9 | 79.1 | 68.1 | 62.2 | 56.1 | 112.0 |
| Feb. | 63.6 | 43.0 | 36.0 | 54.7 | 78.4 | 67.0 | 60.9 | 76.5 | 127.6 |
| Mar.. | 64.4 | 44.7 | 38.0 | 56.0 | 77.8 | 68.4 | 62.5 | 129.0 | 135.8 |
| April... | 65.4 | 46.8 | 41.1 | 56.4 | 78.1 | 69.8 | 65.1 | 104.1 | 112.7 |
| May | 66.9 | 51.2 | 46.9 | 58.4 | 77.0 | 76.4 | 72.7 | 95.4 | 100.4 |
| June | 67.6 | 52.6 | 49.4 | 57.9 | 77.0 | 82.2 | 79.8 | 221.9 | 119.9 |
| July. | 70.5 | 60.1 | 60.8 | 59.0 | 77.2 | 84.1 | 82.6 | 136.3 | 114.5 |
| Aug. | 69.4 | 57.0 | 54.9 | 60.5 | 78.6 | 89.8 | 89.5 | 197.2 | 114.2 |
| Sept. | 68.9 | 54.7 | 49.5 | 63.4 | 78.2 | 90.8 | 90.2 | 101.1 | 115.7 |

1 See Prices and Price Indexes 1913-1928, pp 19-21, 270-289 and 1913-1931, p 15

2 Wholesale prices of Canadian products of farm origin only See Prices and Price Indexes 1913 1931 p. 33, and Monthly Mimeographs 1932 and 1933

3. Wholesale prices of grains, fruits and vegetables

4 Wholesale prices of Animals and Animal Products

5 Including foods, rents, fuel, clothing and sundries, See Prices and Price Indexes 1913-1928, pp 181 185, 290-293 1926 = 100

Prices and Price Indexes 1913-1931, pp 122, and Monthly Mimeographs 1932-1933

6 Monthly Review of Business Statistics, pp 8, and Monthly Indexes of the Physical volume of business in Canada supplement to the Monthly Review of Business Statistics, November, 1932

The index of agricultural marketings declined from 197.2 in August of this year to 101.1 in September. Reduced movement of grains was the chief factor in the decline, this index falling from 224.6 to 106.2. The index of wheat marketings dropped from 231.9 to 111.8. The movement of oats was considerably higher than in August but the movement of barley was greatly reduced.

Live stock marketings increased. The index for August was 74.5 while in September it rose to 78.0. Fewer cattle moved to market but all other classes of live stock were marketed in increased volume.

The September index of cold storage holdings was slightly above that for August Increased stocks of eggs, cheese, beef, mutton and lard were reported while supplies of pork, poultry and veal were lower.

*Exports.*—The summary of the trade of Canada for August (the latest report available) contains interesting figures on exports of Canadian farm products for the twelve months ending August 1933 and for a similar period ending August 1932. When 1932 and 1933 are used in the following discussion the reader will inderstand that reference is to the foregoing periods. Exports of fresh fruits were valued at $7,529,577 in 1932 as compared with $9,110,596 in 1933. Foreign sales of vegetables were $4,253,610 and $3,157,711 respectively. A decline in exports of potatoes from 3,393,915 bushels in 1932 to 1,348,804 bushels in 1933 was largely responsible for the lower sales in 1933. Canned vegetables to the value of $854,167 were exported in 1932 whereas only $481,796 worth were shipped abroad in 1933. Foreign markets absorbed 11,798,100 bushels of barley in 1932 against 3,903,013 in 1933. Oats exported amounted to 13,658,810 bushels in 1932 but only 10,512,562 bushels up to the end of August this year. We exported 10,096,251 bushels of rye in 1932 whereas in 1933 we shipped 1,832,075 bushels abroad. Wheat exports in 1932 were 189,184,106 bushels but in 1933 they rose to 230,499,706. Sales of flour to foreign buyers were 5,191,798 barrels in 1932 as against 5,520,519 in 1933. Exports of maple sugar were 3,327,858 pounds in 1932 but fell off to 2,591,084 in 1933. Flax seed shipped to foreign countries amounted to 189,135 bushels in 1932 but 794,391 bushels were exported in 1933. Our export trade in tobacco has been growing in recent years as is evidenced by the fact that in 1932 we exported 10,341,294 pounds while 14,256,920 pounds were shipped in 1933—largely to United Kingdom.

Shipments of cattle to foreign buyers amounted to 52,172 head in 1932 as compared with 41,622 in 1933 although there has been an increase in exports to the United Kingdon. Exports of bacon and hams were 343,087 hundredweights in 1932 and 545,297 hundredweights in 1933. Our exports of canned meats increased from 378,559 pounds in 1932 to 632,237 pounds in 1933. Poultry exports rose from 1,116,182 pounds to 1,304,495 pounds. Cheese exports continue to decline; in the year ending August 1932 we shipped 955,336 hundredweights as against 695,090 hundredweights in 1933. Condensed milk sold abroad in 1932 amounted to 20,245,000 pounds whereas in 1933 we shipped 30,593,500 pounds. Exports of eggs amounted to 441,474 dozens in 1932 and 291,389 dozens in 1933. In 1932 we exported 3,030,523 pounds of honey but only 2,573,467 pounds in 1933. Exports of wool increased from 5,159,582 pounds to 6,775,387 pounds.

In connection with the foregoing statistical information in regard to exports it may be suggested that it is not only necessary to examine the conditions of supply but also to consider foreign purchasing power, trade policies and exchange rates, as well as the nature of competition from countries exporting similar products. These factors frequently change and have at times limited international trade. Export markets have especial significance for Canadian agriculture and, therefore, these problems warrant the closest study.

## LA SITUATION ECONOMIQUE

### PREPARE PAR LA DIVISION DE L'ECONOMIE AGRICOLE DU MINISTERE DE L'AGRICULTURE, OTTAWA, ET BASE SUR LES DONNEES RECUEILLIES PAR LE BUREAU FEDERAL DE LA STATISTIQUE

Il ne suffit pas de noter les fluctuations quotidiennes ou mensuelles des prix, mais aussi, et surtout, la courbe de ces prix pendant une série de plusieurs mois, et les observations de ce genre paraissent être spécialement indiquées à l'heure actuelle. De 69.4 qu'il était en août l'indice des prix du gros est tombé à 68.9 en septembre. Le chiffre correspondant est de 65.9 pour septembre 1932 et de 66.7 pour août 1932. La diminution notée en septembre de cette année est due principalement à la nouvelle baisse de prix qui s'est produite dans le groupe des produits végétaux. Les matières et les produits textiles ont maintenu leur position; le bois, les produits du bois et le papier ont monté; le fer et ses produits ont légèrement monté; les métaux non ferreux

et leurs produits ont baissé tandis que les minéraux non métalliques et leurs produits ont enregistré une forte hausse. Les produits chimiques et de même nature étaient supérieurs d'une fraction au niveau d'août.

*Prix du détail.*—Il y a eu également une légère hausse dans les prix du détail. Le chiffre d'août était de 78.6; celui de septembre de 78.8.

*Volume physique des affaires.*—L'indice du volume physique des affaires s'est élevé de 89.8 à 90.8 et l'indice de la production industrielle, de 89.5 à 90.2. Ces hausses sont inférieures à celles qui ont été notées en juillet et août de cette année, et cependant elles indiquent une activité commerciale certainement plus forte que l'année dernière, alors que les indices ne sortaient pas des "soixante-dix". En septembre l'indice de la production minérale est monté de 98.0 à 108.8; celui de l'industrie manufacturière s'est élevé d'une fraction, de 96.9 à 97.0. Le bâtiment s'est un peu amélioré, passant de 25.5 à 26.9. L'indice des forêts a baissé de 94.0 à 88.0 et la production du fer et de l'acier est tombée de 46.4 à 43.5. L'indice des ventes agricoles a diminué.

*Embauchage.*—La situation de l'embauchage continue à s'améliorer. Le nombre d'employés salariés sur les listes des maisons qui font régulièrement rapport au Bureau de la Statistique était, au 1er octobre, de 834,348 contre 816,458 au 1er septembre. L'indice de l'embauchage s'est donc élevé à 90.4.

*Produits agricoles.*—L'indice des produits de ferme canadiens, qui était de 57.0 en août, est tombé à 54.7 en septembre. Les produits des champs ont encore vu leurs prix baisser et l'indice est tombé de 54.9 à 49.5. La faible demande d'exportation du blé, l'offre de blé russe et les rapports favorables de l'état de la récolte dans le Sud de l'Australie et l'Argentine ont encore fait baisser les prix du blé. Les prix de l'orge et de l'avoine ont suivi le même cours, mais ceux du lin et du seigle se sont relevés.

L'indice des prix des produits animaux est passé de 60.5 à 63.4, principalement à cause de l'amélioration qui s'est produit dans les prix du lait en nature, des oeufs et de la laine; en général, les prix des porcs et des veaux étaient un peu plus élevés mais les prix des boeufs et des agneaux étaient plus bas.

Quelques faits intéressants se dégagent des comparaisons à long terme:—en septembre 1932 l'indice des produits des champs était de 39.5 et celui des produits animaux de 60.4. En septembre de l'année dernière, l'indice total des produits de ferme canadiens était de 47.3. Si l'on porte la comparaison un peu plus loin on voit qu'en août 1933 l'indice des produits des champs était de 54.9 tandis qu'il était de 42.3 en août 1932. En ce qui concerne les produits animaux l'indice d'août 1933 était de 60.5 contre 58.5 en août 1932. L'indice total pour août 1932 était de 48.4; en outre, si l'on compare l'indice de juillet de cette année à celui de juillet 1932 on voit que les indices des produits des champs étaient de 60.8 et 42.6 respectivement, ceux des produits animaux de 59.0 et 57.8, et les indices totaux de 60.1 et 48.3.

L'indice des ventes agricoles, qui était de 197.2 en août de cette année est tombé à 101.1 en septembre. La diminution des expéditions du grain était la cause principale de cette baisse; l'indice est tombé de 224.6 à 106.2. L'indice des ventes de blé est tombé de 231.9 à 111.8. Il s'est transporté beaucoup plus d'avoine qu'en août mais beaucoup moins d'orge.

Les ventes de bétail ont augmenté. L'indice pour août, qui était de 74.5, a passé à 78.0 en septembre. Il s'est transporté moins de bovins au marché mais plus d'animaux de toutes les autres catégories de bestiaux.

L'indice des produits conservés au froid en septembre était un peu supérieur à celui d'août. On signalait des stocks plus considérables d'oeufs, de fromage, de boeuf, de mouton et de saindoux, mais des approvisionnements plus restreints de lard, de volailles et de veau.

*Exportations.*—Le résumé du commerce du Canada en août (le dernier rapport paru) contient des chiffres intéressants sur les exportations de produits de ferme canadiens pendant les douze mois finissant en août 1933 et pendant une période semblable finissant en août 1932. Lorsque nous employons les chiffres de 1932 et 1933 dans la discussion qui suit, il faut bien comprendre que nous nous rapportons aux périodes précédentes. Les exportations de fruits frais étaient évaluées à $7,529,577 en 1932 contre $9,110,596 en 1933. Les ventes de légumes à l'étranger étaient de $4,253,610 et $3,157,711 respectivement. La diminution dans les exportations de pommes de terre, qui de 3,393,915 boisseaux qu'elles étaient en 1932 sont tombées à 1,348,804 boisseaux en 1933, est la cause principale de la diminution des ventes en 1933. Il s'est exporté en 1932 des légumes en conserves pour une valeur de $854,167 tandis qu'il ne s'en est expédié que pour $481,796 en 1933. Les marchés étrangers ont absorbé 11,798,100 boisseaux d'orge en 1932 contre 3,903,013 en 1933. Les exportations d'avoine ont atteint le chiffre de 13,658,810 boisseaux en 1932; en 1933, à la fin du mois d'août, la quantité exportée n'était que de 10,512,562 boisseaux. Nous avons exporté 10,096,251 boisseaux de seigle en 1932 contre 1,832,075 boisseaux en 1933. En 1932 les exportations de blé se montaient à 189,184,106 boisseaux; en 1933 elles se se sont élevées à 230,499,706. Les ventes de farine aux acheteurs étrangers avaient été de 5,191,798 barils en 1932 contre 5,520,519 en 1933. Les exportations de sucre d'érable, qui étaient de 3,327,858 livres en 1932, sont tombées à 2,591,084 en 1933. La graine de lin expédiée aux pays étrangers se montait à 189,135 boisseaux en 1932, mais en 1933 il s'en est exporté 794,391 boisseaux. Notre commerce d'exportation de tabac a grandi en ces dernières années; en 1932 nous en avons exporté 10,341,294 livres et en 1933 14,256,920 livres, principalement au Royaume-Uni.

La quantité de boeufs expédiés aux acheteurs étrangers, qui se montait à 52,172 têtes en 1932, est tombée à 41,622 têtes en 1933, quoique les exportations sur le Royaume-Uni aient augmenté. Les exportations de bacon et de jambon se montaient à 343,087 quintaux en 1932 et à 545,297 quintaux en 1933. Nos exportations de viandes en conserves ont passé de 378,559 livres en 1932 à 632,237 livres en 1933. Les exportations de volailles, qui étaient de 1,116,182 livres se sont élevées à 1,304,495 livres. Les exportations de fromage baissent toujours; au cours de l'année finissant en août 1932 nous avons expédié 955,336 quintaux contre 695,090 quintaux en 1933. La quantité de lait condensé vendu à l'étranger en 1932 se chiffrait par 20,245,000 livres tandis qu'en 1933 nous en avons expédié 30,593,500 livres. Les exportations d'oeufs se montaient à 441,474 douzaines en 1932 et à 291,389 douzaines en 1933. En 1932 nous avons exporté 3,030,523 livres de miel et en 1933 seulement 2,573,467 livres. Les exportations de laine ont passé de 5,159,582 livres à 6,775,387 livres.

En ce qui concerne les renseignements statistiques qui précèdent sur les exportations, nous croyons utile de dire qu'il ne suffit pas d'examiner la situation de l'offre mais aussi le pouvoir d'achat à l'étranger, les régimes commerciaux et le taux du change, ainsi que la nature de la concurrence que nous font les pays exportant les mêmes produits. Ces facteurs varient souvent et ils apportent parfois des entraves au commerce international. Les débouchés d'exportation offrent une importance toute spéciale pour l'agriculture canadienne, et c'est pourquoi ces problèmes méritent d'être étudiés avec le plus grand soin.

## RESUME DES ARTICLES PUBLIES EN ANGLAIS DANS CE NUMERO

**Impressions de la East Malling Research Station.** R. C. Palmer, Ferme expérimentale fédérale, Summerland, Colombie britannique.

L'organisation de la East Malling Research Station, Angleterre, est décrite et on discute le résultat de quelques-unes de ses recherches. Les hommes de science dans bien des sphères ont cooperé afin d'obtenir des résultats d'une valeur pratique aux éleveurs de fruits. On insiste sur la valeur du travail de recherche fondamental, particulièrement lorsque des hommes s'occupant de différentes sciencs peuvent travailler sous un même directeur et sur le même matériel, le considérant sous ses différents aspects.

LA FLETRISSURE DE L'AUBERGINE. J. K. Richardson, Laboratoire fédéral de pathologie végétale, St. Catharines, Ont.

Il a été nettement établi que le *Verticillium Dahliae* Kleb est responsable de la flétrissure de l'aubergine. Cet organisme produit la flétrissure typique lorsque la température du sol est entre 11°C et 30°C. Il ne la produit plus à 35°C. L'application de divers engrais ne contrôle pas la maladie. L'addition au sol d'une solution de chlorure mercurique avant le repiquage des plants, suive d'applications subséquentes, a contrôlé la maladie en serre, et l'a considérablement retardée en culture à l'air libre.

On recommande les mesures de contrôle suivantes. Obtenir la graine de producteurs n'ayant pas la maladie sur leur terre. Stériliser la semence avant de la planter. Garder les plants en sol stérilisé depuis les semailles jusqu'au repiquage à l'air libre. Ne pas planter d'aubergines pendant plusieurs années à la suite de récoltes susceptibles au *Verticillium* telles que les framboises, les tomates, les pommes de terre, etc. Planter les aubergines de préférence après une céréale, une plante fourragère, ou un engrais vert. Enlever et brûler avant le labour tous les restes de plantes attaquées par le *Verticillium*, aussi bien tomates et pommes de terres qu'aubergines; l'enfouissement d'une récolte malade augmente la quantité d'éléments pathogènes dans le sol. Ne pas jeter de plantes malades sur le tas de fumier ou de compost: c'est la méthode idéale pour contaminer toute une exploitation. Eviter autant que possible de transporter du sol de régions atteintes dans les régions où la maladie n'a pas encore fait son apparation.

ELECTROLYSE DE LA GRAINE DE CEREALES. J. G. C. Fraser et L. M. Pidgeon, Ferme expérimentale centrale, et laboratoire de Recherches national, Ottawa.

Le blé de semence Huron, fut traité aux laboratoires de Recherches national, Ottawa, par le procédé Wolfryn Electro-Chemical, et ensemencé à Charlottetown, Fredericton et Ottawa. Les résultats de cet essai démontrent qu'il ne semble y avoir aucun avantage à employer cette méthode dans le but d'augmenter le rendement du blé Huron.

LA VALEUR ANTIRACHITIQUE DE L'HUILE DE SARDINE DANS L'ELEVAGE DES POUSSINS. Jacob Biely et V. Elvira Palmer, Université de Columbie brittanique, Vancouver, Canada.

Les résultats obtenus dans ces expériences confirment ceux obtenus par d'autres expérimentateurs, à savoir que l'huile de sardine est égale à l'huile de foie de morue médicale ou commerciale pour la production d'un système osseux normal. Les poussins recevant ½% d'huile de sardine ont montré une croissance normale et un développement osseux comparable à celui des poussins recevant 1% d'huile de foie de morue. Ces expériences montrent que l'huile de sardine ordinaire du commerce est aussi riche en vitamine D que l'huile de sardine raffinée. Il est aussi évident que l'huile de sardine ne se détériore pas après être conservée pendant un an dans des conditions convenables.

ETUDE SUR LES QUALITES DE BRASSERIE DE L'ORGE. T. J. Harrison, Bureau des Commissaires des Grains du Canada, Winnipeg, Man.

L'étude de l'effet de la situation géographique sur la qualité de l'orge de brasserie montre que pour le Canada l'Ile du Prince Edouard devrait être à même de produire la meilleure orge de brasserie et que les autres Provinces de l'Est pourraient produire une qualité satisfaisante. En Colombie britannique la qualité varie suivant le sol et les conditions climatériques des diverses vallées. Dans les Prairies c'est le Manitoba qui produit la meilleure qualité, bien qu'une qualité satisfaisante puisse être obtenue dans les parties septentrionales de l'Alberta et de la Saskatchewan. Dans le Manitoba ce sont l'est et le nord qui donnent les meilleurs résultats.

Si l'on considère les variétés d'orge en relation avec les méthodes de brasserie utilisées au Canada, c'est le groupe des orges à six rangs d'origine mandchoue qui donne les meilleurs résultats. Dans ce groupe c'est O.A.C. No. 21 et la Chinoise qui donnent les meilleurs rendements. L'orge de juillet aurait une place si elle était produit en quantité. On ne peut en effet la mélanger à l'O.A.C. No. 21 ni la Chinoise. Le groupe méditérranéen ne se montre pas satisfaisant bien qu'il comprenne des variétés californiennes aussi renommées que Bay-Brewing, Mariout, etc. Parmi les variétés à deux rangs le groupe Chevalier est nettement supérieur au groupe Duckbill. Dans ce groupe les meilleures variétés sont Hannchen et Plumage Archer. Avec les méthodes de fabrication du malt en usage dans le Royaume Uni ce sont les mêmes variétés qui donnent les meilleurs résultats, a savoir, Hannchen et Plumage Archer parmi les variétés a deux rangs, et O.A.C. No. 21 et Chinoise parmi les variétés à six rangs.

# Joseph Jean Robert Marcotte

## 1901 - 1933

Joseph Jean Robert Marcotte, né à Ste Anne de la Pérade (comté de Champlain) le 27 décembre 1901, du mariage du Dr. François Arthur Marcotte, M.D. ex-député de Champlain à la Chambre des Communes et de Dame Alma Marie La Rue; fit ses études primaires à Ste-Anne de la Pérade (Collège du Sacré-Coeur) jusqu'à 1913, puis au Séminaire des Trois-Rivières et au Collège de Lévis pour ses études classiques; de là, il se dirigea vers l'Institut Agricole d'Oka, (1920-24) d'où il est sorti après un stage de quatre années avec le titre de B.S.A.

Ses professeurs et confrères ont gardé un souvenir inoubliable de Robert Marcotte. Son goût prononcé pour les sciences, aidé d'une intelligence de grande envergure l'ont conduit dans les premiers de sa classe. Ses grandes qualités morales, sa bonne humeur, sa gaité, même aux heures tristes de la vie le faisaient rechercher par ses confrères et ses amis.

Au sortir de l'Université, il fit quelques voyages d'étude, entre autres dans l'Ouest Canadien, aux Etats-Unis et après quoi, il assuma la charge de diriger la ferme de son père, médecin, qui n'avait pas trop de temps pour s'occuper de ses malades; il y réussit à merveille.

Après quelques années, c'est-à-dire en 1930, désireux de communiquer à la classe agricole les çonnaissances acquises dans l'étude et le travail, il entre au Département de la Division Fédérale d el'Industrie Animale et depuis lors, notre ami ne se souciait des fatigues du travail ardu qu'il avait à remplir; il fut un apôtre chez les agriculteurs. Là aussi, sut-il capter la confiance et l'estime de tous et en particulier de ses chefs.

Jeune encore, il souriait à la vie, cette vie prometteuse de succès, de gloire et d'honneur. Mais les vues mystérieuses et profondes de la Providence échappent à notre compréhension humaine. Agà de 31 ans et 9 mois, après trois semaines de maladie, le 24 septembre 1933, l'âme de notre cher confrère s'envolait vers les régions heureuses de l'Au-Delà.

Sur cette tombe à peine fermée aux misères et aux souffrances terrestres, mais entr'ouverte déjà aux joies béatifiques, je dépose une gerbe de profondes sympathies et l'assurance d'un pieux et durable souvenir.

Un confrère de travail,

ALBERT DESROSIERS,
Nicolet.

# ANNUAL MEETING OF THE CANADIAN SEED GROWERS' ASSOCIATION

The Canadian Seed Growers' Association held its annual meeting at Regina, Sask., on July 21 and 22, 1933. The various sessions were more than usually well attended by farmer grower members, and an increasing enthusiasm was manifest on the part of growers in the work of the Association.

A comprehensive account of this meeting will be contained in the C.S.G.A. Annual Report. This report contains (*a*) a summary of the proceedings of the business sessions. (*b*) Board of Directors' Report for 1932-33, (*c*) report of the Treasurer for 1932-33, (*d*) reports of C.S.G.A. standing committees, (*e*) reports of plant breeders' committees, (*f*) reports of C.S.G.A. provincial directors and local branch secretaries and (*g*) the ever popular "Growers' Corner" which contains notes and news of interest to C.S.G.A. growers. Any C.S.T.A. member desiring a copy of this Annual Report may receive one on request to W. T. G. Wiener, Secretary, Canadian Seed Growers' Association, 336 Jackson Building, Ottawa, Ont.

To give recognition to grower members who have distinguished themselves in the service of the C.S.G.A., the Association awards Robertson Assoicate memberships. The name "Robertson Associates" was given to this preferred class of membership in honour of the founder of the Association, the late Dr. J. W. Robertson, LL.D., C.M.G., who was a Charter Member and Fellow of the C.S.T.A. Two C.S.G.A. Robertson Associates were elected this year, namely, Dr. C. A. Zavitz, Ilderton, Ont., and Mr. A. C. B. Grenville, Morrin, Alta. The former is well known to C.S.T.A. members being a Charter Member and a Fellow of the Society, and the latter is a veteran seed grower who has also done yeoman service to Canadian agriculture.

Mr. A. L. Searle, President of the Searle Grain Co., Limited, was presented with the first Honorary Membership ever awarded by the Canadian Seed Growers' Association. The certificate of honorary membership, which was presented to Mr. Searle by the President on behalf of the Association, took the form of a beautifully prepared parchment inscribed with the declaration that "Mr. A. L. Searle has been elected an Honorary Member of the Canadian Seed Growers' Association in recognition of his sympathetic support of crop improvement and his interest in the activities of the Association."

Professor T. J. Harrison retired from the Presidency of the Association, a post he has held for four years. Professor R. Summerby was unanimously elected President for the ensuing year and took over his new duties upon the last day of the official sessions.

The officers of the C.S.G.A. for 1933-34 are:

*Honorary President:* George H. Clark, Dominion Seed Commissioner, Ottawa, Ont.

*Honorary Vice-Presidents:* C. A. Zavitz, Ilderton, Ont.; H. G. L. Strange, Searle Grain Co., Ltd., Winnipeg, Man.; L. H. Newman, Dominion Cerealist, Ottawa, Ont.; T. J. Harrison, Dominion Board of Grain Commissioners, Winnipeg, Man.

*President:* Robert Summerby, Macdonald College, P.Q.

*Vice-President:* F. W. Townley-Smith, Lashburn, Sask.

*Secretary-Treasurer:* W. T. G. Wiener, 336 Jackson Building, Ottawa, Ont.

# ANNUAL MEETING OF THE CANADIAN PHYTOPATHOLOGICAL SOCIETY

The Canadian Phytopathological Society held its Third Annual Meeting in Regina, Sask., July 25 to 28, 1933, in conjunction with the Annual Meeting of the Canadian Society of Technical Agriculturists and the World's Grain Exhibition and Conference. The meeting was well attended by the Western members of the Society.

The sessions were held in Regina College. Twenty papers were read before the Society and evoked considerable discussion. These papers were chiefly in the field of Cereal Pathology. Two joint sessions were held when the plant pathologists joined with the agronomists. About one half of these papers were of particular interest to the pathologist. Many of the scientific papers read before the World's Grain Conference were also greatly appreciated by members of the Society. The exhibits at the World's Grain Exhibition were a great credit to the management, the plant Pathological exhibit prepared by the Division of Botany being one of the best ever assembled. The exhibit of living plants graphically illustrating how the inheritance of disease resistance in two or more plants may be combined into a single plant, was particularly good.

A successful business session was held under the chairmanship of Prof. W. P. Fraser, President of the Society. Mr. N. A. MacRae, Assistant Secretary-Treasurer read the minutes in the absence of Mr. T. J. Major, retiring Secretary-Treasurer. M. Etienne Foëx, Versailles, France, was elected an honorary member. Reports of committees were read and approved. Dr. P. M. Simmonds, Chairman of the local committee was especially commended for the excellent arrangements. As the result of a mail ballot conducted in May, the following executive was elected:

*President:* D. L. Bailey, University of Toronto.

*Vice-President:* J. H. Craigie, Dominion Rust Research Laboratory, Winnipeg.

*Secretary-Treasurer:* I. L. Conners, Central Experimental Farm, Ottawa.

*Councellors:* J. G. Coulson, Macdonald College, P.Q.; W. P. Fraser (ex-officer), University of Saskatchewan, Saskatoon; H. T. Güssow, Central Experimental Farm, Ottawa.

## ANNUAL MEETING OF THE WESTERN CANADIAN SOCIETY OF AGRONOMY

The annual business session of the Western Canadian Society of Agronony was held at Regina College on July 28th. From the point of view of the Society, the connection with the World's Grain Exhibition and Conference was very valuable, and interest and attendance exceeded expectations.

Two reports were received from the standing committees. These included a report of the Farm Machinery Committee by Prof. E. A. Hardy of the University of Saskatchewan, and a report of the Cereal Zonation Committee by Dr. J. B. Harrington, also of the University of Saskatchewan. These papers were very interesting and were a continuation of the work of these standing committees which have been operating for the past three years. The matter of the Society disseminating information, in the way of popular articles, was discussed to some extent and the incoming Executive were instructed to approach a number of the members with a view to having them prepare such articles during the coming year. It was felt that a number of projects were being carried out by the Society, and the information obtained from these should be made available.

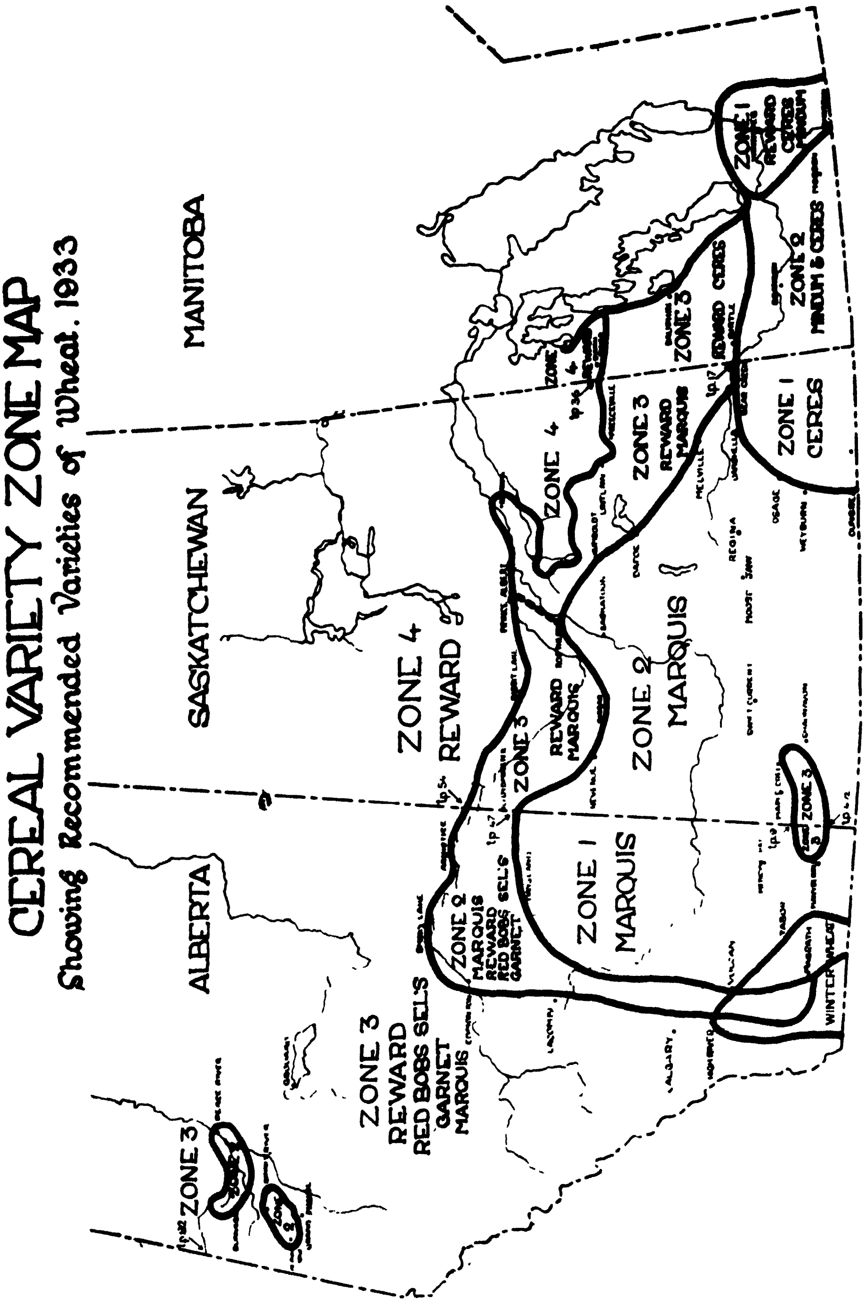
Arrangements for the 1934 Annual Meeting were left to the incoming Executive. The following officers were elected for next year:

*President:* Dr. O. S. Aamodt, University of Alberta, Edmonton, Alta.

*Vice-President:* Dr. J. B. Harrington, University of Saskatchewan, Saskatoon, Sask.

*Secretary:* G. E. DeLong, Dominion Experimental Farm, Lacombe, Alta.

*Directors:* D. A. Brown, Dominion Experimental Farm, Brandon, Manitoba; Dr. J. R. Fryer, University of Alberta, Edmonton, Alberta.



Cereal Variety Zone Map, prepared by the Western Canadian Society of Agronomy Committee in the Co-ordination of Cereal Variety Zones in Western Canada.

## REPORT OF THE COMMITTEE ON THE CO-ORDINATION OF CEREAL VARIETY ZONES IN WESTERN CANADA

The 1932 report of this committee was made at the annual meeting of the Western Canadian Society of Agronomy at Winnipeg in June, 1932, and included a resumé of the establishment of cereal variety zonation in Western Canada. It was published in *Scientific Agriculture* in Volume XIII, Number 7, March, 1933. The zone map, accompanying that report, showed full co-ordination of the existing zone lines but revealed and emphasized the need for a uniform system of zone designations and for a northern forest zone in Saskatchewan, corresponding with the forest zones of the adjacent provinces.

The Cereal Variety Committee of Saskatchewan had recognized the need of a division of Zone A (north and north-east park belt and forest area) into two zones but felt that action should be delayed until completion of the soil survey of that region would enable accurate placing of the new zone line. Last February a fairly complete soil survey map was available for the use of the Saskatchewan cerealists and the desired division of Saskatchewan Zone A into dark soil park belt and bush country was made. Furthermore, the Saskatchewan zone designations were changed to Arabic numerals to conform to those used in Alberta and Manitoba, i.e. 1, 2, 3 and 4 instead of B, C and A. The Saskatchewan cerealists left the precise termination of the new zone boundaries to the Zone Co-ordination Committee to be adjusted fairly with the zone boundaries of Manitoba and Alberta. Due to the excellent co-operation of the Manitoba and Alberta Cereal Committees, the zone boundary co-ordination was easily effected. As for varietal recommendations, the Co-ordination Committee feels that they are remarkably consistent from province to province, according to the conditions found in the different zones. This is particularly true with respect to wheat, the most important crop.

The present zone boundaries of the three Prairie Provinces are shown in the accompanying outline map, together with the names of the wheat varieties recommended in each zone. After the establishment of the new zone line in Saskatchewan, separating zones 3 and 4, it was necessary to move the eastern termination of the line between Alberta zones 2 and 3 and the western termination of the line between Manitoba zones 3 and 4, each slightly to the north, in order that satisfactory link-ups could be made between those lines and the ends of the new Saskatchewan line.

The personnel of the Zonation Committee is as follows: Dr. O. S. Aamodt, University of Alberta, Edmonton; Mr. J. G. Davidson, Dominion Experimental Farm, Indian Head, Saskatchewan, Prof. A. T. Elders, University of Manitoba, Winnipeg; Dr. C. H. Goulden, Dominion Rust Research Laboratory, Winnipeg, Manitoba; Mr. W. D. Hays, Dominion Experimental Farm, Lethbridge, Alberta; Dr. J. B. Harrington (Chairman), University of Saskatchewan, Saskatoon.

After two years of operation, The Varietal Zonation Committee of the Western Canadian Society of Agronomy feels that the lightness and success of its work is due chiefly to the excellent spirit of co-operation existing in and among the three provincial cereal committees.

J. B. HARRINGTON, *Chairman.*

## ANNUAL MEETING OF THE CANADIAN SOCIETY OF AGRICULTURAL ECONOMICS

The annual business session of the Canadian Society of Agricultural Economics was held in Regina College on July 26th in connection with the World's Grain Exhibition and Conference. In view of the fact that the morning sessions of the Grain Conference were largely economic in nature, a heavy programme was not planned for the technical sessions of the Society. The following resolution was passed at the business session.

> "That this Society wishes to go on record emphasizing the need for the establishment of an Agricultural Outlook Service in Canada as previously placed before this organization. We commend the report of the Select Committee on Economics, Marketing and Agricultural Outlook given at the recent Conference called by the Federal Minister of Agriculture and particularly stress the place therein given to the Agricultural Outlook. We also wish to commend the work already accomplished on this project in the Provinces of Saskatchewan and Nova Scotia and the plan followed by these Provinces in the co-ordination of this work in these Provinces."

The officers and executive of the Society for 1933-34 are as follows:

*President:* J. F. Booth, Department of Agriculture, Ottawa, Ont.

*Vice-President:* H. C. Bois, Department of Agriculture, Quebec, P.Q.

*Secretary:* J. Coke, Department of Agriculture, Ottawa, Ont.

*Executive:* T. W. Grindley, Bureau of Statistics, Ottawa, Ont.; H. R. Hare, Vancouver, B.C. (4378 W. 13th St.); W. Allen, University of Saskatchewan, Saskatoon; F. W. Reinoehl, Colonization Finance Corporation of Canada Ltd., Winnipeg, Man.

## ANNUAL MEETING OF THE CANADIAN SOCIETY OF ANIMAL PRODUCTION, WESTERN SECTION

The Sixth Annual General Meeting of the Western Canada Society of Animal Production was held on July 31, August 1, 2 and 3, in Regina, during the World's Grain Exhibition and Conference. Meetings were held in the Armories adjoining the Fair Grounds. The meetings were well attended and much discussion took place on the various papers presented.

The minutes of the 1931 meeting at Saskatoon were reviewed and resolutions read in full. Due to present conditions it was not possible to give any favourable report on the resolutions. The minutes were adopted as printed.

The first order of business was the ratifying of the Constitution of the Canadian Society of Animal Production. This was read to the meeting and the following resolution was moved by Dr. Bowstead and seconded by Dean Shaw:

> "Whereas the Western and Eastern Societies of Animal Production have approved of the amalgamation to form the Canadian Society of Animal Production and the Eastern Canada Society has approved of the Constitution, therefore be it resolved that this Society also approves of the Constitution as read and that the Eastern Canada Society be notified of the same."

The meeting then carried on as the Western Section of the Canadian Society of Animal Production.

The following are the officers and directors for 1933-34:

*President:* G. W. Wood, Manitoba Agricultural College, Winnipeg, Man.

*Vice-President:* C. M. Learmonth, Department of Agriculture, Regina, Sask.

*Secretary-Treasurer:* R. M. Hopper, Dominion Experimental Farm, Brandon, Man.

*Directors for Provinces:* British Columbia—H. Hicks, Dominion Experimental Farm, Agassiz, B.C.; Alberta—L. B. Thomson, Dominion Range Experiment Station, Manyberries, Alta.; Saskatchewan—Dean A. M. Shaw, University of Saskatchewan, Saskatoon, Sask.; Manitoba—J. Bell, Livestock Commissioner, Department of Agriculture, Winnipeg, Man.

## ANNUAL MEETING OF THE HORTICULTURAL GROUP OF THE C.S.T.A.

The activities of the Horticultural Group this year were somewhat curtailed owing to there being so few of the members of this group at the World's Grain Show. The absence of the members was not, however, due to lack of interest in the organization, but largely due to economic conditions. As evidence that interest in this group has not waned, it should be pointed out that a number of reports promised for presentation were in the hands of the chairman. These included a resumé of the activities of the marketing committee by H. J. M. Fiske, Mutual Brokers, Ottawa, Ontario; Report of Committee on Varieties of Fruit, E. F. Palmer, Director, Horticultural Experiment Station, Vineland, Ontario; and the Report of the Committee on History of Horticulture, R. P. Gorham, Entomological Laboratory, Fredericton, N.B.

To facilitate hearing Sir Daniel Hall, Director, John Innes Horticultural Institute, London, England, the reading of the minutes of the 1932 meeting, as well as the reading of the above reports was dispensed with owing to the very limited time available.

The chief item of interest was a very fine address by Sir Daniel Hall, dealing with the behaviour of diploid and triploid plants and the application of this knowledge to plant breeding. Following the address a number of slides were used to illustrate the various points of interest mentioned in the previous part of the address.

The appreciation of the members was extended to Sir Daniel Hall by Mr. W. R. Leslie, acting chairman.

## ANNUAL MEETING OF SOILS GROUP OF THE C.S.T.A.

A departure from the programme arrangement of the prevoius year was that the business sessions were held apart from the technical sessions. The business meetings, held at Regina College, on Wednesday and Thursday mornings, July 26th and 27th, were devoted to discussion of the affairs of the Soils Group and to the presentation and discussion of the reports of the various committees appointed at the previous convention.

Due to the absence of the chairman of the Group, Professor G. N. Ruhnke, the vice-chairman, Professor A. H. Joel occupied the chair, with Prof. A. Leahey as secretary.

Decisions of the meeting affecting the activities and policy of the Soils Group were:

1. To remain as a Soils Group within the C.S.T.A. rather than set up an independent organization. This decision prevents the inclusion of non-members of the C.S.T.A. in this section unless the consent of the parent organization is obtained.

2. Revision of the list of soil workers and their activities, this work to be done by the secretary with the aid of corresponding secretaries appointed by the executive, one for each province.

3. That a committee be appointed by the executive to report on the laboratory methods used by the various colleges and institutions in Canada.

4. That the chairman and secretary of the Group be selected from the district where the next convention is to be held.

No action was taken with regard to the question of affiliation with other soil organizations. Professor J. H. Ellis urged that members of the Group on their own accord should become affiliated with the Imperial Bureau of Soils.

The report of the Committee on Research and Experimental Projects in Soils prepared by Professor G. N. Ruhnke was presented by A. H. Joel. The work of this committee, although well advanced, is not yet completed. The meeting decided to ask Professor Ruhnke to carry on this work to completion and urged that members of the Group give him their fullest co-operation.

The report of the Genetic Soil Map Committee was presented by Professor A. H. Joel. A very interesting map showing the genetic classification of the soils in Canada was the main feature of this report. Steps are being taken to make this map available to the various interested institutions.

The following executive was elected for the coming year:

*Chairman:* Dr. E. S. Hopkins, Central Experimental Farm, Ottawa, Ont.
*Vice-chairman:* Dr. A. Leahey, University of Alberta, Edmonton, Alta.
*Secretary:* Dr. R. R. McKibbon, Macdonald College, P.Q.

## Report of the Chairman of the Genetic Soil Map Committee

At a meeting of the Soils Group at the Winnipeg Convention, 1932, the writer presented a paper entitled, "The Preparation of a Genetic Soil Map of Canada." The paper was published in *Scientific Agriculture* in the issue of October, 1932. Following the discussion of the paper, the group requested the writer to appoint a committee to work on the project and to act as chairman of such a committee. The following committee was appointed:

Dr. D. G. Laird for British Columbia.
Mr. C. C. Kelley for British Columbia.
Dr. F. A. Wyatt for Alberta.
Prof. A. H. Joel for Saskatchewan.
Prof. J. H. Ellis for Manitoba.
Mr. F. F. Morwick for Ontario.
Dr. R. R. McKibbon for Quebec.
Prof. Auguste Scott for Quebec.
Prof. L. C. Harlow for Nova Scotia.
Mr. E. M. Taylor for New Brunswick.
Dr. J. A. Clark for Prince Edward Island.
Dr. E. S. Hopkins for the Central Experimental Farm, Ottawa.

The Committee has worked actively during the year and has produced the first tentative general soil map of Canada. The necessary information was submitted by the various members of the committee and the map was prepared by the chairman.

The map was presented at a Soils Group Meeting at Regina Conference. The soils of British Columbia were discussed by Dr. D. G. Laird, those of Alberta by Dr. F. A. Wyatt, those of Saskatchewan by Prof. A. H. Joel, and those of Manitoba by Prof. J. H. Ellis. As the other committee members were not present, soils of the remaining provinces were discussed by Prof. A. H. Joel, the discussion being based on information previously submitted by the representatives of these provinces. The reception of the map was very encouraging and the discussion of the soils of the various provinces most stimulating. It became evident that the map would be very useful in the future in connection with the discussion of soil problems in various parts of Canada.

It was recommended at this meeting that the committee continue its work, particularly to revise and add to information already collected.

The chairman offered to circulate a copy of the map among the committee members during the coming year for copying, in order that at least one map would be available in each province. As soon as some necessary additions and revisions are made on this original map, this will be done. A copy of descriptions of the various soil groups will also be sent with the map.

A. H. Joel, *Chairman.*

## ANNUAL MEETING OF THE ENGINEERING GROUP OF THE C.S.T.A.

The second annual conference of the Agricultural Engineering Group of the C.S.T.A. held at Regina College during the World's Grain Exhibition and Conference was a decided success. Though the programme was a very heavy one every paper was presented. At several of the sessions of this group the attendance ran between forty and fifty. This group also constituted itself as the Canadian Section of the American Society of Agricultural Engineers, of which society most of the group are members, the same executive serving both organizations.

So far as the interests of this group are concerned, the World's Grain Conference performed an inestimable service in bringing together farmers, college professors and research men, and engineers from the farm implement firms. There are many problems in Agricultural Engineering, and indeed in agriculture generally which can best be solved by the united efforts of men from these three specialties. It is to be hoped that this conference will prove to be merely the first of many such gatherings.

Agricultural Engineering was given a prominent place when the Grain Conference Programme Committee invited Mr. E. J. Stirniman, Consulting Agricultural Engineer of Brooklyn, Iowa, to open the conference sessions on the evening of July 24th with a paper on "The Mechanization of Agriculture in Russia." During the group sessions twenty-four papers were read on various economic and technical problems of mechanization.

The following are executive officers of the Agricultural Engineering Group of the C.S.T.A. for 1933-34:

*Chairman:* F. L. Ferguson, Ontario Agricultural College, Guelph, Ont.

*Vice-Chairman:* E. A. Hardy, University of Saskatchewan, Saskatoon, Sask.

*Secretary:* L. G. Heimpel, Macdonald College, P.Q.

## ENTOMOLOGICAL SESSIONS
## WORLD'S GRAIN EXHIBITION AND CONFERECNE

The entomological sessions of the World's Grain Conference were organized by the chairman of the Entomological Programme Committee, Mr. Arthur Gibson, Dominion Entomologist.

The activities involved four public conference meetings and two business meetings of the International Great Plains Conference of Entomologists, the latter group meeting with and forming an integral part of the conference.

The programme included twenty-three authoritative invitation papers upon the most significant grain pests, the list embracing grasshoppers, wireworms, pale western cutworm, Hessian fly, chinch bug, European corn borer, wheat stem sawfly, hairy spider beetle, "Insects Injurious to Rice in Siam" and "Pests of the Wheat Crop in India."

The several sessions were carried on under a rotation of chairmanships including Mr. Arthur Gibson, Entomological Branch, Ottawa, Canada; Dr. W. H. Larrimer, Bureau of Entomology, Washington, United States of America; Prof. E. H. Strickland, University of Alberta, Edmonton, Alberta and Prof. A. G. Ruggles, University of Minnesota, St. Paul, Minnesota, United States of America, who also presided over the business sessions of the associated group.

The International Great Plains Entomologist's Conference is a rather loosely organized group of prairie entomologists who meet annually. Prof. A. G. Ruggles was elected chairman for 1934, the next meeting to be in Minnesota, U.S.A., at the time and place selected by the chairman.

The conference was of the greatest inspiration and value, particularly to the Canadian participants. It occurred in a year of a period of great insect activity when the most aggressive application of control measures over very wide areas was necesasry to the prevention of the loss of literally millions of bushels of wheat and other grain. Under these circumstances the review in conference by leaders in grain pest control work through formal address and discussion had a very definite and direct application to the solution of pressing Canadian problems. Such applications have since been made upon many hundreds of thousands of acres of prairie land in protection of Canadian crops.

The Canadian entomologists especially, therefore, recognize that they rest under a deep obligation to the World's Grain Exhibition and Conference for providing the opportunity to hold such a conference at such an auspicious moment.

## W. F. GEDDES HEADS GRAIN RESEARCH LABORATORY

The appointment of Dr. W. F. Geddes to head the Grain Research Laboratory of the Board of Grain Commissioners at Winnipeg has been announced. Dr. Geddes, one of the leading cereal chemists on the North American Continent, has been Professor of Agricultural Chemistry at the University of Manitoba since 1925. As

Secretary of the Associate Committee on Grain Research of the National Research Council, he has been in close touch with all cereal research work conducted in Canada. Many of his own researches have been published in *Cereal Chemistry* and the *Canadian Journal of Research.*

During the past few months Dr. Geddes has been working in co-operation with the National Research Council on the durum wheat problem. Experimental equipment which he has been using will be moved to the research laboratory of the Board of Grain Commissioners and further studies in the milling of semolina and the manufacture of macaroni and spaghetti will be conducted.

## NEWS ITEMS

W. B. Gornall, (N.S.A.C. '09) recently appointed Fruit Commissioner to Great Britain, has arrived in England. His business address is Walter House, Bedford St., Strand, W. C. 2, London, England.

John Walker (Alberta '24) is taking post graduate work in horticulture at the University of Minnesota, St. Paul, where his address is 1393 Cleveland Avenue, St. Paul.

B. J. Sallans (Manitoba '21), Assistant Plant Pathologist, Dominion Laboratory of Plant Pathology, Saskatoon, was married on Oct. 6th to Miss Margaret Lockhart of Vancouver.

F. T. Shutt, (Toronto, D.Sc.) Dominion Chemist and Assistant Director of the Dominion Experimental Farm System, has recently retired. Dr. Shutt's divisional staff presented him with a very fine camera and the Central Experimental Farm staff presented him with a grandfather clock. An afternoon reception was held at the Director's home and Dr. Shutt planted an oak tree on the grounds of the Central Farm.

W. A. F. Hagborg (Manitoba '29), is now located at the Dominion Rust Research Laboratory, Winnipeg, in the capacity of Plant Disease Investigator.

A. W. Peterson (McGill '21), Dominion Live Stock Branch, Ottawa, who was listed in the September issue of *Scientific Agriculture* as Assistant Chief in charge of Cattle and Swine, should have been listed as in charge of Swine work.

E. G. Bayfield (Alberta '23), Agricultural Experiment Station, Wooster, Ohio, has recently been made a Fellow of the American Association for the Advancement of Science.

C. A. Lamb (British Columbia '21), who is taking post-graduate work in plant physiology at Cornell, is located at 319 Dryden Road, Ithaca, N.Y.

H. M. Scollie (Toronto '28), formerly of the Chemistry Department, Ontario Agricultural College, Guelph, is now located at Apartment 11, 621 Spadina Avenue, Toronto.

W. E. Walker, (Saskatchewan '17) has changed his address to 117 Eighth St., Saskatoon, Sask.

Donald Cameron (Alberta '30), who has recently returned to Edmonton after enjoying a three months travelling scholarship in Scandinavian countries, is now in the hospital at Edmonton with appendicitis.

G. B. Rothwell (Toronto '05), Dominion Live Stock Commissioner, has rceently returned from a trip to the Old Country where he has been studying the live stock marketing situation.

Wm. Allen (Saskatchewan '22), Professor of Farm Management, University of Saskatchewan, has been appointed a royal commission of one man to conduct a general inquiry into milk prices in Saskatchewan. George Curtis, Regina, will be Secretary to Dr. Allen.

A. T. Charron (Ottawa '92), Assistant Deputy Minister of Agriculture, was married on the eighteenth of September to Alphonsine Mercier of Montreal.

SCIENTIFIC AGRICULTURE

Vol. XIV. DECEMBER, 1933 No. 4

# THE RELATION OF AGRICULTURAL SERVICES TO CHANGING CONDITIONS[1]

SIR E. JOHN RUSSELL[2]

Mr. President and gentlemen:

I am going to talk to you tonight about agricultural conditions in Great Britain as they affect the Agricultural Adviser, the man who, in our country, is known as the County Organiser; and I will also touch on conditions as they affect the Canadian agriculturist. In order, however, to understand present conditions in British agriculture, or indeed in world agriculture, it is necessary to know something of how they arose. For in agriculture, as indeed in most other human activities, the best key to the present is the history of the past.

For many years, and right up to comparatively recent times, agriculture had developed in the direction of enabling each region, sometimes each village, to be self-supporting. Transport was practically non-existent for bulky agricultural products; whatever the local farmers could not produce people had to go without. From time immemorial there had of course been transport for such costly things as metals, precious stones and luxury articles, but transport in food is a recent development. The old system of agriculture, both in Great Britain and also in Canada—the old French system—was, therefore, necessarily one of mixed farming in which each farm produced a certain amount of live stock, of cereals and other food stuffs for human beings and for animals, as well as flax, wool and hides to make clothing and other necessary articles for human use; even oil was often produced on the farm from colza and rape.

Then came in bewildering succession the marvellous discoveries of the 19th Century which made it one of the most brilliant epochs in human history: discoveries in science which revealed for the first time to the astonished gaze of mankind something of the infinite wonder and complexity of the world in which we live, and yet of the underlying orderliness and regularity which the scientists of those days expressed by strikingly simple generalizations—now known, however, to be only approximations to the truth, the generalizations as we know them being much more complex. There were equally striking advances in practice, which resulted from applying the new scientific knowledge to the problems of everyday life. One of the most remarkable of these practical achievements had been the discovery of artificial fertilizers, made at Rothamsted about 90 years ago but based on the earlier work of the plant physiologists and greatly influenced by Liebig, of which we are naturally proud. The first Rothamsted field experiments showed these self-supporting farmers how to increase their yields considerably and without difficulty. Prior to this discovery the average yields of wheat in Great Britain, though not known precisely, had been somewhere about 20 bushels to the acre. Within about twenty years of the discovery the yields had been pushed up to about 30 bushels, and other crop yields had similarly increased. Along with the development of the artificial fertilizer industry in Great Britain came other improvements in agriculture, and the net result was a considerable increase in yield, and, perhaps even more important, in certainty of yield. It was the first time that science had been applied to agriculture and the result was a great success. It did not, however, alter the system; this still remained general and self-sufficient.

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[1] An address delivered to the Canadian Society of Technical Agriculturists at Ottawa, August 14, 1933.
[2] Director, Rothamsted Experimental Station, Harpenden, Herts, England.

Later on, however, there came those engineering developments of railways and steamships that opened up these lands of Canada and the United States, and made it easy to transport commodities from here to Great Britain. The first commodity to be sent over in any quantity was wheat. It was grown here and in the United States more cheaply than in England and consequently was put on to our markets at prices with which our farmers could not compete. Many of them, therefore, had to give up wheat growing as a principal occupation; they retained the crop, of course, but it became a subsidiary product in our agriculture, and for many farmers this is what it still remains: some grow it to feed their poultry, others for the sake of the straw. Several of our agricultural systems require a certain amount of straw, and wheat is a very convenient source of supply. Other farmers grow wheat after expensive crops, like potatoes and mangolds which are fertilized heavily; they do not like growing these crops on the same ground year after year because of the danger of disease. After one crop has been taken off, some other is sown which is so different that it cannot carry the same diseases, and wheat is one of the most convenient for this purpose. Following as it does a heavily fertilized crop it needs no additional fertilizer and but little cultivation; good yields of 40, 50 or even 60 bushels per acre are, therefore, obtained easily and cheaply and so we have been able to continue wheat growing in competition with you. But it is essentially a secondary product.

This bringing of wheat from Canada and the United States on to our market at prices below which our farmers could grow it was the first break in our ancient self-sufficient system of agriculture. In general, however, our political leaders did not worry very much about that. They were greatly impressed by the possibilities that these new developments of science and transportation were opening up. The world seemed to be shrinking very much in those days of seventy or eighty years ago, and there arose a great school of liberal thinkers in our country, who worked for an ideal that Tennyson expressed in glowing words, "the Parliament of man, the Federation of the world". They saw the ancient barriers of time and distance breaking down and the whole human race becoming one family. Their ideal was that each region should produce the things for which it was best suited, and that the nations of the globe should work together in peace and friendship, each one contributing what it best could to the common stock which they called the World Market, and all exchanging their commodities without any artificial restrictions. It was the great doctrine of Free Trade. There were to be no barriers, no hindrances whatever to the free exchange of the goods which each nation could produce. Western Canada for instance, could produce our wheat; Eastern Canada could supply us with apples, dairy products, and bacon; Australia could send wool and more wheat; New Zealand, lamb and dairy products; and South Africa, certain fruits. All these, and the products from other parts of the world were to be received by us in exchange for coal, iron and manufactured articles which we could send out. That quite naturally led to the idea of specialization; each region, instead of being self-supporting, was now to specialize in those things which it could produce best.

It was not, however, these doctrinaire considerations, but sheer necessity that drove our farmers to specialize according to their local conditions. In the eastern parts of England where we have a low rainfall, some 24 inches annually fairly evenly distributed, much of the land remained arable and was, and still is, used to produce cereals and other arable crops. In the western parts of England where the rainfall is 30 inches and more, up to 70, 90 or even 100 inches, grass is the appropriate crop, and so this region produces livestock and its various products, milk, dairy products and young animals for sale to arable farmers. Other specialized regions also developed, devoted to fruit, market gardening, potato and vegetable production, dairy husbandry and other activities. One great advantage of this specialization was that it enabled our farmers to take full advantage of modern developments in agricultural science. They became experts, seeking improvements all the time in order to raise the yield or enhance the quality of their products or lower the cost of production, and they could appreciate the results of agricultural experiments bearing on their problems. They could recognize also the need for them, and it cannot be too strongly impressed upon the political leaders in any community at the present time that the more agriculture becomes specialized the greater is the need for scientific work. The general farmer can afford to make a few mistakes; if he loses on one crop he always has three or four other commodities that may bring him out all right. But the specializing farmer cannot afford to take any chances; he has staked everything on his specialized products, and he must have all the help the man of science can give him in order to avoid the possibility that anything should go wrong. Along with specialization, therefore, comes the need for a strong agricultural research advisory service to discover underlying principles and new facts, then to apply this knowledge to farm problems, and finally to pass the information on to the farmer, interpreting it in language which he can understand and making experiments on ordinary commercial farms to find out just how the new knowledge can best be used in practice.

A further advantage of this specialization is that it leads to improved conditions for the farmer, higher and more certain yields, lower costs of production, and, therefore, greater prosperity for him and for the farm workers. The old system of self-sufficiency often meant a low standard of living such as is still found among the peasants of many parts of Europe, especially in Eastern Europe. It is not uncommon there for peasants to work and work well for a very small return; probably its cash value would be little more than five cents per hour. That is not the kind of remuneration that appeals to our workers, or to yours; but these peasant people, these small general farmers who lack the aid given by science, are not yet in a position to obtain more.

That, then, was the great agricultural movement up to the time of the war; a change over from general farming to specialized farming, and it came about as the result of the development of transport. The first product to suffer had been wheat, but gradually other products came into our markets as well; before long no agricultural product was safe from competition. To meet this our farmers became more specialized, thereby calling forth the need for the fuller development of agricultural science.

Then came the war with its complete dislocation of all ordinary channels and services of trade, its breakup of the fine adjustment between supply and demand. Of course that seriously affected the specialization arrangements because it meant that commodities no longer flowed easily and naturally from one country to another: hindrances of one kind and another grew up in the form of tariffs, exchange difficulties, and monetary restrictions, but there was an even greater effect: during the war inventors had been busy and they had developed a new invention, which, while certainly known before the war had not figured very largely in our civilization—the internal combustion engine. This was the child of science: it was the direct outcome of purely chemical work done on explosions in gases, very interesting as chemistry but apparently of no practical value. Then followed much chemical and metallurgical work on the properties of new alloys: again interesting but much of it apparently of academic interest only. But suddenly, the practical application came when engineers showed that these explosions, if carried out in cylinders, could be made to drive pistons, and the new alloys furnished metals of sufficient lightness and strength to enable them to construct engines that would work. So the internal combustion engine developed, and in due course was introduced into agriculture. That had the immediate effect of lightening the work of the farm and speeding up the operations, but later on, with the post-war improvements, it went far beyond what it had ever done before, and began displacing men from the land. You all know how far this has gone already, but no one knows how much further it may yet go. I was looking up the records of one of our wheat fields just before I left for Canada. In the year 1852 we had required 65 men to harvest that field in one day. Last year it was harvested with four men, using, of course, a tractor. And that process of displacing men has already gone far in England, not only in our agriculture, but in our other industries also, and it still continues. This displacement of the man from the land, the factory, and the office is creating a great army of unemployed people who are no longer needed for the only job they know how to do, and who see no prospect of ever being wanted again. One farm of 900 acres in England that has recently been mechanized, formerly employed 40 men and afterwards employed only 4, the other 36 having been disbanded. I asked what had become of them and was informed that only 10 had then found other work: most of the rest were on relief works, being subsidized heavily by the community, or were unemployed. If we try to work out a balance sheet to see how much the community has gained by the replacement it really doesn't appear to be much, because by the time the displaced men and their families have been maintained the community has spent a good deal that would have been saved had these men remained on the farm and produced food at rather higher cost than the machine could do it.

That is one of the great problems confronting us to-day. We are bound to go on developing agricultural science and practice, and engineering science and practice, and yet the more they are developed the worse this problem of displaced men is likely to become.

A third great factor that has profoundly affected British agriculture is the wave of nationalism that has spread over the civilized world since the war. Every country now aims at being an independent unit, not only the large ones, but also the Eastern European countries liberated as a result of the war from the great Empires into which they had been constrained: Poland, Czecko-Slovakia, Lithuania, Latvia, Estonia, Jugo-Slavia and others. For the first time they are feeling themselves free, independent units—like boys just liberated from school. For the first time for many years they are assured of their independence, and of their opportunity to develop themselves in their own way. The older countries are inspired by the same desire to be self-contained and independent of the rest of the world, to produce all they want, importing nothing but only exporting. And, although it passes the wit of man to discover how a country that makes importation difficult can ever hope to make exportation easy, most countries are now trying it. The favourite method is to set up high tariff walls so as to shut out the products of other nations and give their own nationals a chance to develop, an ideal with which one cannot quarrel. Big nations can indisputably do what they like within their borders, and it is equally certain that the small nations have a perfect right to live and to develop themselves in the way they consider best. Some of them we know are highly gifted people who can contribute greatly to the richness of life in our civilisation. And so, although one regrets the disadvantages of this new birth of national spirit—the birth-pains, perhaps one might call them—and the suffering that has been brought about by all these restrictions on trade and movements of human beings, nevertheless we cannot quarrel with the underlying idea, nor deny these nations their right to independent development on whatever lines appeal most to them. A very difficult situation resulted from these new nationistic developments, and particularly from the attempts made by each country to export, but not to import. There were so many exporters, and so few importers, that prices fell very much, and many governments helped their exporters in one way or another so that they could send out goods at less than the cost of production. That affected us very much, because, as ours was practically the only free market in Europe, we had things dumped on to it at prices with which our farmers could not possibly compete. Several factors enabled the Continental farmers to beat ours in low costs of production. Many of the Continental farmers can obtain good labour very cheaply. But our farmers are not allowed to employ labour at low wages. They are subject to a minimum wage rate, fixed by law, of thirty shillings a week for adult agricultural labour. This, of course, fixes a minimum cost of production below which the English farmer can not compete. Our farmers also suffered from another kind of competition. In a good many parts of the world, and in some parts of the Empire, the home market is protected, so that farmers can sell their products at a price sufficient to cover the cost of production of their whole output: they can then put their excess produce on the world market at any price it will fetch. Some countries go further and subsidize exports.

Transport had developed so remarkably well that distance no longer protects the farmer. Liquid milk, it is true, cannot yet be carried far, and it is indeed the only agricultural product for which our farmers have any natural protection. But butter can be brought from New Zealand in five weeks, and although it has to cross the equator, transport is so perfect that it arrives in splendid condition on our tables. Lamb comes in great quantities from New Zealand and Australia, and so efficient are the transport arrangements that when it is cooked an ordinary person can hardly distinguish it from fresh English lamb. Plums, peaches and apricots come all the way from South Africa and suffer no loss of quality; the plums arrive with the bloom on them, as fresh as if they had just been taken from the tree. Our farmers might have competed against these various products if wages and other conditions were the same all over the world; but they cannot unaided compete against superior natural conditions, lower rates of wage, or subsidized exports, nor can they compete against men guaranteed a home market and sending only excess produce on to our market at any price it will fetch. All our agricultural products were affected, and we felt that there was not a single thing left which the English farmer could produce at prices that would even bring back the cost of production, let alone any profit.

Two or three ways of meeting the situation were tried. It was soon recognised that the problem could not be solved entirely by scientific workers. It was no use for us to discover new and cheaper ways of production, because, of course, the information is at once given out to the whole world, and other countries can proceed to put it into practice so far as they think it helpful to them. Science proudly and indefatigably boasts that it knows no boundaries and will acknowledge no nationalism or indeed any other political dictation; by a fine tradition it generously gives its results freely to all for use or application as they may think fit. Rothamsted has always been open to any scientific worker from any part of the world once he can get to England. We commonly have specialists from other countries working at our station, collecting all the information we can give them, and we are very glad to have them. The discovery by scientific workers of newer, easier, and cheaper ways of producing things would simply mean that everybody would adopt them, and we should all be left exactly where we were.

Science thus seemed helpless. But something had to be done. Our agriculture was getting into a terribly serious position, especially in the eastern counties where the conditions are not favourable to grassland and cheap milk production. Farmers were becoming more and more involved in debt; they were reducing staffs, cutting down all expenditure, and their farms were deteriorating. Prices were falling continuously, and our markets were so glutted with imported cheap food that much farm produce became almost unsaleable. Finally the situation became so critical that the Government decided to take the very drastic step of stopping the indiscriminate free importations of food and putting the whole business of food supply on a definitely organised basis.

Of course, it meant giving up Free Trade (or at least free, unrestricted import) and it took our people a long while before they were prepared to give up the old idea of free trade in food, or indeed in anything else. But no alternative could be devised: the opponents could only recommend farmers to go on hoping, a very unsatisfying proposal.

Two methods of control were very seriously considered once it was recognised that the farmer had to be helped. One was the method of putting tariffs on imported foodstuffs. That met with a good deal of favour at first, but the more it was discussed the more serious were found to be its disadvantages. I need not go into the question of exactly what they were: probably the most serious was that the town people did not like it, and in our country, as you know, nine-tenths of the people live in the cities and have to buy their food, and the suggestion of a tax on anything they themselves buy is repulsive. The second method was more popular. It involved the allocation to the home farmers of a certain proportion, called the quota, of the home market, guaranteeing at the same time an agreed price so arranged as to cover a reasonable cost of production and leave a small margin for the farmer. The quota for wheat is 15%; our farmers are told that they can supply 15% of our wheat requirements and that the price given will be forty-five shillings a quarter, i.e. $1.39 per bushel. They can, if they like produce more than that, but they won't get the guaranteed price for anything beyond the 15%; they must dispose of any excess as best they can.

Similarly with other agricultural products; a quota of some kind is arranged and farmers are guaranteed a certain proportion of the home market and a certain price for it. The working out of the scheme is delegated to various non-political and non-government Commissions and Marketing Boards formed of representatives of the producers, the distributors, and the consumers. This method of procedure is making it possible to arrange for contracts between farmers and buyers. Instead of the farmer producing hopefully for a market day where he may receive much or little according to the relative abundance of scarcity of products, he can now work on a contract to supply certain quantities of produce at a certain price; he knows, therefore, what his receipts will be and he can arrange to spend a certain amount on fertilizer, on new implements, better seed, and other equipment. His certainty of some return puts him on the alert for new methods of improving his production.

This system of contracts implies, of course, that the farmer shall maintain a high standard of efficiency and pay his workers a wage corresponding with the price received. You cannot expect any city population to remain content with arrangements that can be represented as keeping up prices of food if there be any suggestion of inefficiency on the part of the farmers; a highly efficient farming community and a satisfactory standard of labour alone can justify the continuance of artificial quotas or the contracts that they imply.

These considerations are making it necessary for our agricultural experts and advisers to consider carefully their duties to the farming community in these new conditions. We have two great functions to perform. First of all we must discover the facts and the underlying principles of crop production and of animal production—finding out how the plant grows, what changes take place when you cultivate the soil, what fertilizers do, how the animal grows and multiplies, how diseases affect the plant and the animal and how they act. This information is required not only for the use of the expert himself, but also for the purpose of building up a sound system of agricultural education; because unless the farming community is adequately educated you cannot expect the town community to support them by agreeing to any restrictions of food prices. With that call for improved agricultural education has come a fuller recognition of the vital importance of more and more knowledge of the fundamental principles underlying agricultural processes, and this in turn has brought into prominence the necessity for still more fundamental work in biochemistry, soil chemistry, soil physics, and biology; subjects that, not infrequently, have been regarded as purely academic, as luxuries permissible in times of prosperity but legitimate subjects for retrenchment in days of adversity. Yet all experience shows that these so-called academic subjects furnish the material out of which the agricultural expert fashions the soundest advice and the best educational courses for the young farmer. You can not build up a permanent system of agricultural education on simply empirical knowledge; it must be based upon scientifically ascertained facts and principles. Nature is one and indivisible, and although we may find it convenient to distinguish between science and applied science, yet the lines are of our own invention and have no existence in reality.

In England we are not only trying to develop our agricultural education but also to improve the method of presenting it. This, of course, is mainly the business of the educationalist, but the agricultural expert must also know something about it so as to discover how best to shape his material before handing it over to the teacher. Personally I am very interested in this question of rural education, especially in school teaching. When I first turned over to agricultural science from pure chemistry I used to spend one afternoon each week in the village school teaching the children something about the countryside around them. I can no longer do that, but for half an hour every alternate week I broadcast to rural school children during their school hours. Many of our country schools have radio sets, and the British Broadcasting Corporation arranges for talks each afternoon on rural science, travel, geography, history, music—either piano or good gramophone records with explanations by a first class musician. At Rothamsted Dr. Keen and I undertake the rural science course and we justify the giving up of the necessary time (which however is not very much) by the consideration that the rising generation must learn early to appreciate the value of science and accustom themselves to it, just as they early get accustomed to machines and learn to appreciate their value.

And so we go to London every two weeks and spend half an hour talking to the school children in remote country districts, telling them of the inner meaning of many of the things they see happening round about them in the fields and in the school garden: the germination of the seed, the changes brought about by cultivation, the feeding of the plants and animals, giving them in simple language the elementary scientific principles underlying all these things. We hope in the end to build up a new attitude towards science in our countryside, to train up a race of young country people accustomed from the outset to the ideas of science, and who will therefore be able to take the fullest possible advantage of the extension services available to them.

This, of course is in addition to the more usual work of giving farmers' lectures; and I should like to digress for a moment to say how in recent years the interest of farmers in agricultural lectures has increased. When I first went lecturing, twenty-six years ago, I used to have to give the lecture in a room at the hotel on market day after the market was finished. It was often difficult to get an audience, and sometimes the bar (where of course good liquor was to be had in plenty so long as a man could pay for it) proved a very serious counter-attraction. Often one had to stop after about fifty minutes as the men lost interest, and often too the questions were poor and the discourse worse. But now-a-days when you go lecturing to a farmers' audience you not uncommonly find that the secretary has taken the biggest hall in the town, and that there is a good audience of farmers who have come in by automobile, prepared to stay and listen for as long as you will talk; sometimes the lecture and discussion have to be stopped because the chairman wants to get home. That change has come about because farmers now appreciate much more fully than before the war the part that science plays and must continue to play in agriculture.

All this has quite naturally put upon the agricultural expert the need for further developing agricultural science and for discovering by direct experiment the things that he proposes to tell to farmers, because it is no use talking out of your head to a crowd of farmers; you have to base your talk on actual experiments or good field observation, so that you know the things you say are true because you have seen them for yourself. With the improvement of agricultural science has come a strengthening of the relations between the scientific worker and the farmer, and I am very hopeful that out of the trials and troubles of to-day there will arise new and higher standards in our science and practice. As I see the future our farmers will continue to specialize, yet they will be able to diversify their farming sufficiently well to have two or three strings to their bows instead of only one, so that they may be reasonably sure of a moderate return for their labour.

How do these developments in British agriculture affect Canada? You supply us at the present time with about 50% of the wheat which we import. The 15% which the new quota gives to our farmers is not I think likely to affect you in the slightest degree. First of all, ours is not the same kind of wheat as yours; it is a soft, and not a hard red wheat, and it is not a wheat that our millers like to use to any great extent; 15% is about as far as they are likely to go. A new use has recently developed for English wheat: it is much used for poultry feeding, and it so happens that poultry are markedly increasing in our country so that the amount of wheat they require—which is already considerable—is likely to increase still further; I cannot, therefore, see that our wheat quota is going to injure Canada's exports to us.

You used not to send us 50% of our imports of wheat, indeed it is only quite recently that you have sent so much. Before the war your share was only about 25% but you have increased at the expense of the United States and of Russia. It would of course be interesting to speculate on whether either of these countries is likely to get back sufficient of their old trade to reduce your 50% appreciably. I shall certainly not venture a prophecy, but I cannot see either of them doing that for some long time. Agriculture in the United States seems likely to develop along other lines than the export of wheat. Russia may become a more serious competitor but during the last two years she has sent us but little wheat, and this year practically none. I went through Russia in 1930 to see what I could of the wheat position, and I am expecting to return next Easter, but at present it hardly appears likely that Russia greatly will injure you as a competitor. I think, therefore, you are reasonably safe in regard to wheat.

With regard to your other products, let us take apples first. We receive from you about one quarter of our total import of apples. But the States send us far more: they supply half our import requirements. It is for you to find out the reasons for this and see if you cannot capture a great deal of the American apple trade. It is not easy because they send us very good stuff which is well known and respected on our markets. We have, of course, a considerable production of apples in England, and this is increasing but there will long be room for you because our consumption is going up. Englishmen especially enjoy three kinds of fruit: apples, bananas and oranges; of these we consume about equal quantities, and very much more than of all other fruits put together. You can, I think, hope for a much bigger trade with England in apples than you have yet developed.

You send us a good deal of cheese, indeed you are second on the list of our suppliers. The first place is held by New Zealand which sends us 2½ times as much as you do—over 1,700 thousand cwt. per annum, against a little over 700 thousand cwt. from Canada. The New Zealand supply has increased while yours of late has not. The New Zealand dairy farmer, however, has many advantages you lack. He can keep his cows out to grass for ten or eleven months of the year and he need give them little but the natural pasture, the beautiful green grass of their dairying valleys. For only a few weeks in the year need the animals be kept indoors and the very competent New Zealand agricultural experts are continually striving to shorten this winter feeding period by improvements in management and fertilizer treatment of the grass. You will therefore always be liable to serious competition from New Zealand, but after all New Zealand is not a very big country, and the dairy regions in New Zealand are not as extensive as yours: they are mainly confined to the plains and valleys. In the hills dairy work is much less promising.

Before the war you used to send us a fair amount of bacon and you still send a little, but only one-eighth of your earlier supply, and only 5 out of every 1000 lbs. that we import. Canadian bacon had indeed disappeared as a distinct article in England. Nearly three-quarters of our imported bacon comes from Denmark, and the Danes have secured this enormous hold on our market because they have taken the trouble to supply precisely the article that our wives want. They have discovered the exact degree of fattiness and of streakiness required in various regions of Great Britain, the proper amount of salt to put in, and the right shade of taste and of quality, with the result that they put bacon on our market which is exactly and precisely what our wives want; and so, naturally, our wives buy it and will continue to buy it, and no system of quotas, preferences, or anything else will prevent them doing it. The English housewife is a very independent-minded person, and you simply cannot make her buy what she doesn't want. She may not always know what she does want, but she knows when she hasn't got it. If you send her the sort of bacon she doesn't want it will remain unsold. You have a lot of hard work before you if you want to oust the Dane from our bacon market.

Looking at all the Canadian agricultural products, I think perhaps your easiest job is to increase the supply of apples. Cheese also you should be able to send over in larger quantity, especially the better qualities. But for all these products there will always be need of a great amount of really hard scientific work if you are going to expand your sales and especially if you want to supply new products and secure a position in markets that you have not yet exploited. One thing you have in your favour, a very strong sentimental preference for anything from Canada. Any article labelled Canadian is sure to attract attention and can be pretty sure of a first sale. But before sending new articles into our markets I strongly recommend you to ascertain by trial that they are what the market wants. If our wives don't like them they will not buy them again, and you will be in danger of losing that enormously valuable asset, their desire to buy things from Canada. Of course all this necessitates a great deal of work at the agricultural experiment stations and colleges to discover what is meant by quality, and how quality is affected by differences in treatment and in environment. This is one of the most difficult of all agricultural investigations, but the successes already attained show that it can be carried out with a considerable measure of success.

However, with all the help of science, and the kindly office of the extension officer and other well-wishers, life can never be made entirely easy for the average farmer. He may be protected by quotas or tariffs and helped by scientific advice as much as you like, but he must always take risks; it is usually a choice of evils, and he has to decide between one or more courses of action neither of which he would choose to take, but he has got to do it. The farmer's life is well illustrated by an incident I once met with in the west of Ireland. There was a great stir because a lady of seventy was going to marry a gentleman of seventy-one. But the matter was explained quite simply by one of her neighbours: "The winter is coming on and the peat has to be got in for fuel and the potatoes have to be lifted and brought in; it was a case of either marrying a husband or buying a donkey." Well, that is very much the farmer's situation. He is called upon to choose between two courses neither of which is exactly what he would like to do. Our job as agricultural experts is to give him more alternatives, to try to make the various possibilities better for him, and the decision between them more easy.

Your farmers, like ours, and you with them just like us, are now passing through times of great stress and great anxiety. But you can find much ground for hope if you look back and think what the farmers of bygone days had to go through when they first came here, and out of the wild forests made the smiling countryside of Eastern Canada thickly set with comfortable farm homes and attractive little towns. Those old French settlers who gave so much to Canada, and the early British settlers who followed them, went through vastly more suffering than anyone now is called upon to face. We do but risk money: they risked their lives. With all our financial anxiety we still possess all that has been handed down to us and all that we have ourselves made: good roads, pleasant homes, towns, healthy surroundings, waters, electricity, and a thousand amenities of which they never dreamed. And it is much the same for the prairie farmers: contrast their lot now with that of the early settlers. Fortunately for us the records of the Red River settlement were kept, so we know something of their sufferings: how in 1813 a group of Highlanders sent out by Lord Selkirk broke the ground with a hoe, and struggled with English wheats year after year, always failing yet always striving and hoping. The first year the crop was taken by the birds, in later years sometimes by Indians, or more birds, or it failed. Finally after six years all their difficulties seemed overcome: a rich harvest was in sight, when lo! out from the west came a cloud of grasshoppers and devoured everything—wheat, garden produce and every green herb in the colony. The chronicle goes on to say: "This sudden and unexpected disaster was more than they could bear. The unfortunate emigrants, looking up toward heaven, wept." I always think it speaks volumes for their good Scotch upbringing that they did no more than that.

However great your troubles now appear, you in Canada can look back with pride on the spirit of endurance that enabled those earlier settlers to win through all their trials and troubles—which after all were far greater than those of our day. It is your duty and your privilege to rekindle that wonderful spirit of endurance; to keep alive the flame of undying hope and imperishable faith in the future of your country; to foster

" . . . . . . . . th' unconquerable will,
And courage never to submit or yield."

If you persevere through these dark days you will win through, just as they did. Stand firm, then, so that, in the years to come, men may look back upon these days as times when Canada was learning new lessons, and fortified by new experiences passed through the dark portals of today to a brighter hope and promise for tomorrow.

# SOME ASPECTS OF THE OVERSEAS MARKETS FOR CANADIAN HONEY[1]

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[Received for publication November 6, 1933]

A study of the geography of world production and consumption of honey for recent years shows that the surplus-producing countries have been largely those of the western hemisphere—North, Central and South America and the West Indies—together with New Zealand, Australia and Russia. The importing countries of major significance have been but two in number—Germany and the United Kingdom. Although during the post-war period Netherlands, Denmark, France, and Italy have been regular or intermittent importers of honey, they have not occupied a position comparable in importance to that of Germany or the British Isles. This paper will be restricted to a consideration of the market situation and outlook in the two first-mentioned importing countries.

## THE GERMAN MARKET SITUATION

Germany, considered over a period of years, has held virtually undisputed sway as the heaviest importer of honey for domestic consumption. Gaining steadily after the period of inflation and currency stabilization which ended in 1924, Germany's honey imports reached a total in excess of 21,000,000 pounds for the year 1929. This is to be compared with 11,000,000 pounds for the United Kingdom also at a post-war peak in that year.

As might be expected, German honey imports have shown a heavy decline for 1930 and 1931, standing in the latter year at slightly less than half of the 1929 total. Economic depression and disorder combined with a heavy tariff increase at the beginning of 1930 may be considered as the chief contributing causes. This point will be touched upon later.

German honey imports, over the period noted, have been furnished chiefly by the United States, (mainly California), Cuba, Chile, Guatemala, Haiti, Dominican Republic, Russia, and Mexico. Imports of Canadian honey have been negligible, rarely exceeding 2% of the total and comprising less than 1% for the year 1931.

From the standpoint of the German consumer, honey can perhaps best be described as a "conventional luxury". While much more widely used than in England or possibly than on this continent, there is a strong tendency toward curtailment in times of economic stress. Substitution by artificial honey is also a possibility. An evenly granulated, full flavored honey of medium light (light or light amber) colour meets with the most widespread consumer preference. There is no reason to believe that inability to meet these requirements has had any effect in keeping Canadian honey from this market.

## THE OUTLOOK IN THE GERMAN MARKET

Any future change in the status of Canadian honey on the German market must necessarily be in the way of improvement since honey from the

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[1] The data and analysis upon which this paper is based were assembled and undertaken as part of an industry analysis of California bee culture. Voorhies, Edwin C., F. E. Todd, and J. K. Galbraith. Economic Aspects of the Bee Industry. California Agr. Exp. Sta. Bul. (in press). Also Honey Marketing in California by the same authors. California Agr. Exp. Sta. Bul. 554: 1-31. July, 1933.

[2] Giannini Foundation of Agricultural Economics.

Dominion has never been sold there in significant quantities. It would be fatal however, to look in too sanguine a fashion upon development under such conditions. From the short-time point of view it is to be noticed that German imports are in a state of severe decline—a decline which is a joint function of two particularly cancerous factors—tariff[3] and depression. It is of further significance that the decline in imports fell heavily on honey from the United States, which had previously supplied from one-quarter to one-third of the total. This honey, like that from Canada, is of desirable quality and is merchandised in a reasonably acceptable manner. Production and export of this quality has become geared to a considerably higher price than is required to bring Cuban, Haitian, or Chilean honey on the market. Canadian honey of the lighter grades, at the same price as Cuban honey, would unquestionably outsell it. At the same time the Cuban producer can probably continue to put his crudely produced, barrelled product on the German market at prices lower than those which will entice the Canadian producer. Under present conditions in Germany the consumer, whatever his taste, must buy the cheapest product obtainable. In terms of a familiar economic dogma, the West Indies produce low-quality honey at comparative advantage, while the Canadian or United States beekeeper produces a higher quality product also at comparative advantage. With current demand shifting to the former in the German market, the short-time outlook does not appear hopeful.

TABLE 1.—IMPORT VALUE (PER POUND) OF HONEY FROM BRITISH WEST INDIES, NEW ZEALAND, CANADA AND CHILE AT UNITED KINGDOM PORTS, 1925-1931. (EXPRESSED IN PER CENT OF VALUE OF UNITED STATES HONEY)*

| Country | 1925 | 1926 | 1927 | 1928 | 1929 | 1930 | 1931 |
|---|---|---|---|---|---|---|---|
| United States | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| British West Indies | 83 | 85 | 90 | 84 | 95 | 82 | 75 |
| New Zealand | 105 | 102 | 118 | 141 | 151 | 149 | 126 |
| Canada | 133 | 121 | 113 | 124 | 112 | 134 | 103 |
| Chile | 87 | 68 | 71 | 65 | 70 | 74 | 50 |

* The average yearly import value of honey (per pound) coming into United Kingdom ports from the more important sources of supply is shown. In each year the average per-pound value of honey from the United States is represented as equalling one hundred and hence the per-pound value of honey from other countries becomes a per cent of the average value of United States honey for that year. (Computed from Trade of the United Kingdom, annual issues.)

Taking a longer-time viewpoint, and assuming the eventual recovery of economic order, there is little doubt that Germany will again increase purchases of honey. Assuming the equally unpredictable amelioration of tariffs, this increase would unquestionably be accentuated. In the light of past developments it seems logical to assume that demand for better-quality honey will accompany this change. Given an aggressive and well organized merchandising policy there is every reason to believe that Canadian honey will participate in this market with an equal or even differential advantage as compared with the product from other countries. The nature of German-consumer preference may further open a market for certain stronger flavored or slightly darker honeys than find favour in the home or British market.

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[3] The German tariff on honey, expressed at par of exchange, was increased from approximately 4⅓ to 7 cents a pound at the beginning of 1930 and from the latter figure to approximately 10.8 cents a pound in 1933.

## THE BRITISH MARKET

The United Kingdom ranks second to Germany as a world honey market[4] but from the standpoint of Canadian producers is easily the most important of the two. Honey imports by the United Kingdom have ranged between seven and ten million pounds in recent years and have not shown the drastic decline which has characterized German imports during the depression period.

Until 1928 the United Kingdom drew its honey supply from three main sources—United States, British West Indies, and New Zealand. Canada, Cuba, Chile and other countries contributed somewhat smaller amounts. Within the last three years, however, Canadian honey has made striking progress on this market taking second place among the various competing countries in 1931.

An important sequel to this development is to be gleaned from an examination of the relative per-pound valuation of honey imported by the United Kingdom from different sources. Taking the import valuation of United States honey on a per-pound basis as equalling a hundred for each of the years from 1925 to 1931, New Zealand and Canadian honeys commanded a substantial premium ranging in the case of the latter from 3 to 34% (Table 1). Honey from the British West Indies, chiefly Jamaica, has never been very satisfactorily standardized and prepared for export. The price at which it comes on the British market is apparently in keeping therewith.

Turning to the extent and nature of consumer demand in the United Kingdom it is worthy of note that per-capita comsumption of honey is by no means as high as in Germany. Particularly is this so in what we may be pleased to call "ordinary times". Honey in England occupies a position in the diet not dissimilar to that on this continent and is best described as an occasional breakfast sweet and spread. A Ministry of Agriculture and Fisheries Bulletin summarizes consumer preference as follows: "Light-coloured extracted honey sells more readily than dark-coloured although in the north of England dark honey sells more readily than in the south . . . . in general clear and set honeys are in about equal demand. A set honey of about the consistency of cream is generally preferred to solid, coarsely set honey."[5] It will be observed that there is nothing in the above statement which is otherwise than favourable to well merchandised Canadian honey, particularly the clover honeys.

## THE OUTLOOK ON THE BRITISH MARKET

The initial consideration of the outlook for Canadian honey on the British market reveals a decidedly different picture to that for Germany. Here the product is found to be well established and relatively well known. Tariff troubles do not appear imminent although the fact that two of the three leading competitors are also British countries does not indicate any substantial differential advantage in this regard. Unstable currencies react against honey exports as against other export trade but this situation can scarcely be conceded to be permanent. The United Kingdom, while using a smaller volume of honey than Germany, pays a higher price per pound and requires a higher quality. That Canadian honey is meeting consumer requirements is being demonstrated.

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[4] Imports of the United Kingdom in 1931 were slightly in excess of those of Germany. Reference here is to the years 1925 to 1931 inclusive.

[5] Ministry of Agriculture and Fisheries, Report on the Marketing of Honey and Beeswax in England and Wales, p. 18-19. 1931.

At first glance there can be little doubt that the British market presents a not unfavourable picture to the Canadian producer. On the other hand the vitally important fact remains that the purchasing power of the British consumer will continue to determine in large measure the volume of honey that can be moved on this market at any given price, or the price at which any given volume can be moved. The outlook for honey in the United Kingdom, as for other products, remains not exclusively but in large part a function of the prosperity of the country. Likewise it depends on the closely related factor of ability to make purchases abroad as determined by the willingness of other countries to make reciprocal purchases from the United Kingdom. The exploitation of a market cannot be long sustained as a one-sided process.

Finally it should be noted that Canada has in New Zealand a quality-producing and aggressively-merchandising competitor. Poor crop conditions have kept New Zealand out of the British market to some extent in 1930 and 1931, perhaps furnishing thereby a propitious opportunity for Canada. The condition will presumably not continue and should there be any curtailment in progressive sales policy on the part of Canadian producers, the result might be unpleasant to predict. There is also Jamaica, with perhaps unequalled honey resources, making strong efforts to overcome a long-standing and not entirely unjustifiable discrimination against her product on the British market.

## SUMMARY

1. The surplus honey producing areas of the world are in North, South and Central America, the West Indies, New Zealand and Russia. Germany and the United Kingdom are the great importing countries.

2. The German market, to which Canada supplies but negligible quantities, draws primarily from United States, Cuba, Chile, Guatemala, Haiti, St. Domingo and other countries. Tariffs and depression have greatly reduced imports since 1930.

3. The British market, for which United States, British West Indies, Canada and New Zealand are the main sources of supply, has been better maintained during the depression period. Canada has increased her relative place and Canadian honey prices are relatively above those of other countries except New Zealand.

4. The outlook for Canadian honey in the German market is not favourable from the short-time standpoint. From a longer-time point of view prospects are somewhat brighter. In the British market Canada at present occupies a relatively favourable position. Maintenance of this position will require a continuance of progressive sales policy.

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The data, upon which the foregoing paper is based, have been drawn from primary and secondary sources far too numerous for individual mention (see footnote 1, page 1). Statistical material was derived from:

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2. Trade of the United Kingdom. Monthly and annual issues.
3. United States Department of Commerce, Bureau of Foreign and Domestic Commerce: Foreign Commerce and Navigation of the United States. Monthly and annual issues.
4. United States Department of Commerce, Bureau of Foreign and Domestic Commerce. Unpublished data.

# ABSTRACT

# STUDIES ON BACILLUS CALMETTE-GUERIN (B.C.G.) AND VACCINATION AGAINST TUBERCULOSIS

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[Abstract prepared from Canadian Journal of Research 9: 128-136, 1933][2]

This paper summarizes the results of a long investigation made by the Dominion Department of Agriculture at the Animal Diseases Research Institute, Hull, P.Q., into the question of vaccination of cattle against tuberculosis. The studies and trials have extended over a period of eight years. The observations and conclusions are clearly presented and make a valuable contribution to this much discussed and controversial subject of B.C.G. vaccination.

The first part of the report deals with the study of resistance to tuberculosis of cattle vaccinated with B.C.G. and, for comparison, of unvaccinated cattle. These cattle were exposed for various periods of time to natural sources of tuberculous infection. The conditions to which the animals were subject from the time of birth for the whole duration of the resistance and immunity trials are clearly set down. Exposure to infection was by natural means, through the ingestion of raw milk, followed by cohabitation with tuberculous cattle in stables and in pastures. The hazards of exposure were equalized as far as practicable by alternating the locations of individuals and groups of animals in stables and in pastures, and with the object of maintaining environmental and feeding conditions and sources of infection comparable to those prevailing in a herd of tuberculous cattle on a farm. The total number of cattle is 107, of which 72 have completed their trial. These, consisting of 44 vaccinated cattle and 28 unvaccinated controls, died or were killed. Their ages range from 2 months to 4½ years and in each case a thorough necropsy under laboratory conditions, microscopical examinations and animal test inoculations were carried out. Regardless of age or the duration of the trial, it was found that the percentage of cattle free from tuberculosis was approximately the same for the vaccinated as for the unvaccinated, namely 20.5% and 21.4%, respectively.

The cattle are divided into five age groups, between one year and under and up to four and a half years, and figures for each group are given in tabulated form. Some difference in favour of the vaccinated cattle up to 18 months of age is indicated, but in all cattle over 2 years of age, both in vaccinated and unvaccinated, tuberculosis was present to a greater or lesser degree. Although there is but little difference in the incidence of tuberculosis in the vaccinated and unvaccinated groups, there is some evidence of a greater degree of resistance in cattle up to 2½ years of age, and as judged by the kind and extent of tuberculous lesions revealed at autopsy. Extensive tuberculous involvement was found in 26% of the vaccinated and 53% of the unvaccinated groups under 2½ years of age, but in trial durations of 2½ to 4½ years the percentage of cattle with slight, moderate and extensive tuberculosis, 25%, 25% and 50% respectively, is the same for the vaccinated and unvaccinated groups, and no greater resistance was shown by the former than by the latter. Such increased resistance as may follow B.C.G. vaccination of new born calves declined and soon disappeared under exposure to infection and with the approach of early maturity, and was apparently lost in young cows under the strain of gestation and lactation. Approximately 80% of the cattle developed tuberculosis to a variable extent, but at a slower rate of development and progress in the early life of the vaccinated animals, thus indicating some increased resistance which possibly would be more pronounced if vaccination could be applied under conditions where the exposure to infection is slight and resistance is not broken down by the heavy strain to which breeding cattle, and especially dairy cattle of high production, are subjected.

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[1] Chief Pathologist.

[2] Acknowledgement is made to Dr. Watson for his courtesy in preparing this enlarged abstract of his paper for readers of *Scientific Agriculture.*—Editor.

TABLE 1.—VACCINATED AND UNVACCINATED CATTLE FREE FROM TUBERCULOSIS

| Age groups | Number of cattle | | | Free from tuberculosis, % | |
|---|---|---|---|---|---|
| | B.C.G. | Controls | Total | B.C.G. | Controls |
| Up to 1 year | 5 | 4 | 9 | 100 | 75 |
| 1 to 1½ years | 8 | 3 | 11 | 25 | 0 |
| 1½ to 2 years | 14 | 9 | 23 | 14 | 33 |
| 2 to 2½ years | 9 | 4 | 13 | 0 | 0 |
| 2½ to 4½ years | 8 | 8 | 16 | 0 | 0 |
| All cattle | 44 | 28 | 72 | 20 | 21 |
| *(Cumulative)* | | | | | |
| Up to 1 year | 5 | 4 | 9 | 100 | 75 |
| Up to 1½ years | 13 | 7 | 20 | 54 | 43 |
| Up to 2 years | 27 | 16 | 43 | 33 | 37 |
| Up to 2½ years | 36 | 20 | 56 | 25 | 30 |
| Up to 4½ years | 44 | 28 | 72 | 20 | 21 |

TABLE 2.—VACCINATED AND UNVACCINATED CATTLE WITH TUBERCULOUS INVOLVEMENT

| Age group | Number of cattle | | With tuberculosis, % | | | |
|---|---|---|---|---|---|---|
| | | | Slight | Moderate | Extensive | Total |
| Up to 1½ years | B.C.G. | 13 | 38 | 8 | 0 | 46 |
| | Controls | 7 | 28 | 28 | 0 | 56 |
| 1½ to 2½ years | B.C.G. | 23 | 30 | 35 | 26 | 91 |
| | Controls | 13 | 8 | 15 | 52 | 76 |
| 2½ to 4½ years | B.C.G. | 8 | 25 | 25 | 50 | 100 |
| | Controls | 8 | 25 | 25 | 50 | 100 |
| All cattle up to 4½ years | Totals:— | | | | | |
| | B.C.G. | 44 | 32 | 25 | 22 | 79 |
| | Controls | 28 | 18 | 21 | 39 | 78 |

The second part of the report covers a long period of laboratory propagation and study of the Calmette-Guérin tubercle bacillus. It is recalled that this bacillus, B.C.G., originated from a highly virulent bovine strain and that, according to Calmette and Guérin, during 13 years of cultivation on a special bile-potato media its virulence was slowly attenuated, first for one species of susceptible animal and then for another until, in 1921, after 230 serial passages, it was said to have completely lost all power to produce tuberculosis. B.C.G. vaccination consists of the injection into the animal or human body of these living, attenuated tubercle bacilli, and the possible danger that might arise from this procedure has long been a very contentious question and the subject of many investigations in different countries, with not a little conflict in the reported results.

Three B.C.G. cultures were received direct from the Pasteur laboratories in France, one in the year 1924, the second in 1925, and the third in 1927, each of which was propagated for succeeding generations up to the year 1932, and tested at repeated intervals for virulence and pathogenicity. In all, tests of 145 subcultures, representing descendants to the 121st generation, were made on over 500 guinea pigs. In approximately 56% of the test animals there was no evidence of tuberculosis. Slight, or localized, or apparently healed lesions were found in 40% of the guinea pigs, but typical tuberculosis, reinoculable from animal to animal, in series, or by reisolation of the culture and subsequent inoculation, developed in 4% of the test animals. Actually, only 6 of the 145 cultures tested proved to be virulent for guinea pigs, and these were able to cause progressive tuberculosis, reinoculable from animal to animal. It is interesting and significant to note that these 6 virulent cultures were obtained at different periods and from different generations or descendants between the years 1924-1928 inclusive, the first strain furnishing 3 virulent descendants, the second, 2 virulent descendants, and the third 1 virulent descendant. During four years of subsequent cultivation none of the cultures tested proved to be virulent for guinea pigs. Each strain was found to possess an unfixed potential virulence, manifested but rarely and only in the 1924-1928 descendants. Continuing under serial cultivation and periodic return to the special bile-potato media which served for the attenuation of the original cultures, virulence has apparently disappeared and none of the later descendants tested, since 1929, have caused a progressive reinoculable tuberculosis in laboratory animals. These results offer a confirmation of the reported experiments and evidence by a number of investigators in different countries in disproof of the claim that B.C.G. was completely and absolutely devoid of virulence and that its properties were hereditarily fixed, especially in connection with the cultures distributed in the years 1924-1927.

The conclusion reads as follows:

"At this present time we can make the statement on positive proof evidence that the parent strains of B.C.G., as they came to us, and their early descendants possessed an unfixed potential virulence capable of exaltation on the one hand and of further and complete reduction on the other, each of which has been accomplished; and, on negative evidence, that the latter descendants of the same strains (1929-1932), by continuous reproduction and periodic return to bile media in accordance with Calmette's recommended procedure, have become incapable of causing progressive, reinoculable tuberculosis in laboratory test animals."

# A STUDY OF THE RELATION OF ENVIRONMENT TO THE DEVELOPMENT OF THE UREDINIAL AND TELIAL STAGES OF THE PHYSIOLOGIC FORMS OF *PUCCINIA GRAMINIS AVENAE* ERIKSS. AND HENN[1]

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[Received for publication November 2, 1933]

## INTRODUCTION

The classification of the physiologic forms in *Puccinia graminis avenae* Erikss. and Henn., as in most cereal rusts, has been based upon the assumption that the types of infection produced by the various forms on differential hosts in the seedling stage were not significantly different under various environmental conditions. The validity of this assumption has been questioned in recent years. Wide fluctuations have been observed to occur in the types of infection produced on certain differential hosts apparently due to a change in the environment. The present study was undertaken to determine the relation of certain environmental factors, particularly temperature, to the development of the physiologic forms of *P. graminis avenae.*

The relation of the environment to two stages of development of the physiologic forms of this rust was determined. First, a study was made of the types of infection produced by the uredinial stage on certain varieties and strains of *Avena* spp. used as differential hosts; and, second, of the formation of the telia by the different physiologic forms.

The greater part of the study was concerned with the relation of one environmental factor. temperature, to the development of the physiologic forms, although the effects of ultra-violet radiation and atmospheric humidity upon them also received attention.

This investigation was commenced in 1929 at the Dominion Rust Research Laboratory, Winnipeg, Manitoba, and a preliminary report (*15*) was published in 1930. Since that time the work has been continued and extended, part being done in the Dominion Rust Research Laboratory and part in the Department of Plant Pathology, University of Wisconsin, Madison, Wisconsin.

## PHYSIOLOGIC SPECIALIZATION IN *Puccinia graminis avenae*

### REVIEW OF LITERATURE ON PHYSIOLOGIC SPECIALIZATION IN *Puccinia graminis avenae*

The composite nature of *Puccinia graminis* Pers. was demonstrated by Eriksson (*5*) in 1894. At this time the stem rust of *Avena* spp. was recognized as a distinct biologic race of *Puccinia graminis* and was termed *Puccinia graminis* f. *avenae.* Although further specialization was shown to occur in *Puccinia graminis tritici* by Stakman and Piemeisel (*42*) in 1917, it was not demonstrated in *P. graminis avenae* until 1923, when Stakman, Levine and

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[2] Plant Pathologist.

Bailey (*45*) reported the occurrence of at least four, and possibly five biologic forms in this rust.

In 1925, Bailey (*1*) gave the results of a more intensive study of the problem and showed that, of the five physiologic forms isolated, forms 1, 2 and 5 occurred in the United States and Canada. Forms 3 and 4, more virulent than the others, were not isolated from any collections of oat stem rust made in America. Form 3 was shown to occur in South Africa and Sweden, while form 4 was isolated only from a collection of oat stem rust obtained in Sweden. A further study by Bailey (*2*) of collections of *P. graminis avenae* made in Canada in 1924 showed that forms 1, 2 and 5 were present again, but that forms 3 and 4 were apparently absent.

Gordon and Bailey (*14*) in 1928, demonstrated the existence of six physiologic forms of *P. graminis avenae* in Canada. These forms were isolated from approximately 600 collections made in Canada during the three-year period 1925-1927. In addition to forms 1, 2 and 5 already known to occur there, forms 3, 4 and 6 were isolated for the first time. Form 6 is the most virulent physiologic form of oat stem rust yet isolated, as more than 300 varieties and strains of *Avena* spp. are susceptible to it. Although forms 1, 2 and 5 were the most prevalent, a few isolations were made of forms 3, 4 and 6.

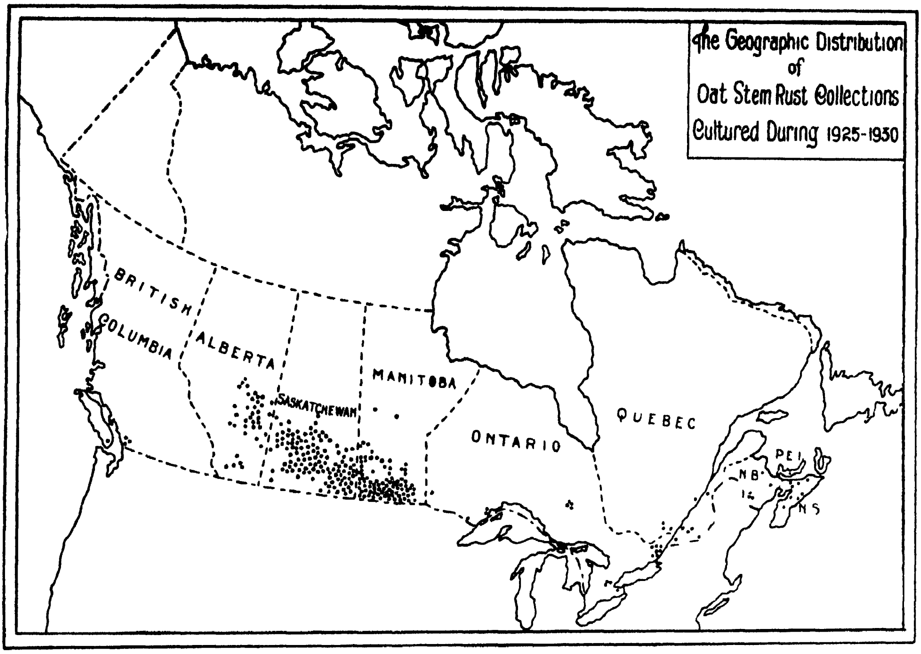
Waterhouse (*54*), in 1929, reported five physiologic forms of *P. graminis avenae* as occurring in Australasia. Forms 1 and 2 were found by him to be the most prevalent and widespread during the period 1925-1929. Forms 6 and 7 were isolated only during the years 1928 and 1929. Form 3 was first isolated in 1929. Forms 1 and 7 were also isolated by him from cultures derived from a barberry which had been artificially inoculated with teliospore material collected in Ireland. The cultures of these two physiologic forms differed in colour from the Australian forms of oat stem rust. While the cultures of Australian forms, according to Ridgway's Colour Standards, were classified as "morocco red", these were "xanthine orange".

In 1930, Levine, Stakman and Stanton (*27*) reported the occurrence of forms 1, 2 and 5 in the United States during the five-year period 1923-1927. Form 2 was the most prevalent physiologic form there during this period. Form 1 was isolated commonly, but form 5 was found to be present only in 1927. Although they were unable to isolate and identify the specific forms, evidence was obtained which showed that physiologic forms of *P. graminis avenae* more virulent than forms 1, 2 and 5 probably were present during 1923 and 1924.

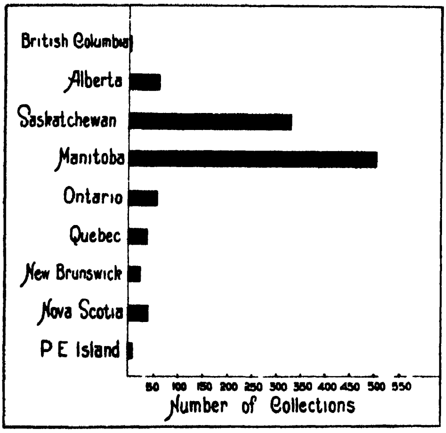
The results of an investigation of the physiologic specialization of *P. graminis avenae* in Sweden were reported by Tedin (*51*) in 1930. From a study of the types of infection produced on the differential hosts by a number of collections of oat stem rust, it is apparent that five physiologic forms are present there. These are forms 3, 4, 6, 7 and 8—all more virulent physiologic forms than those prevalent in the United States and Canada.

## PHYSIOLOGIC FORMS OF *Puccinia graminis avenae* PRESENT IN CANADA DURING THE PERIOD 1925-1930

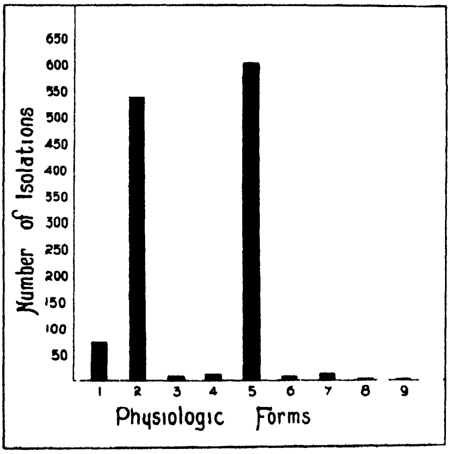
An extensive study of the physiologic specialization in *P. graminis avenae* in Canada was carried on at the Dominion Rust Research Laboratory,


The Geographic Distribution of Oat Stem Rust Collections Cultured During 1925-1930
BRITISH COLUMBIA
ALBERTA
SASKATCHEWAN
MANITOBA
ONTARIO
QUEBEC
PEI
NB
NS

Text Figure 1. The geographic distribution of the oat stem rust collections cultured during the period 1925-1930.



Text Figure 2. The total number of collections of oat stem rust cultured from each province during the period 1925-1930.



Text Figure 3. A comparison of the total number of isolations of the nine physiologic forms of *P. graminis avenae* made in Canada during the period 1925-1930.

Winnipeg, Manitoba, during the six-year period 1925-1930. Collections of oat stem rust were obtained each year from the different provinces and were cultured in the greenhouses. The geographic distribution of these collections is shown in Text Figure 1. The total number of collections of oat stem rust cultured from each province during the period mentioned is shown by means of a graph in Text Figure 2. The relative prevalence of the rust geographically and the facilities afforded for obtaining the collections governed the number cultured each year from the different provinces. From a total number of 1070 collections cultured, 904, or approximately 85%, were obtained in the Western Provinces, as is shown in Table 1. The majority of the collections cultured were secured from the provinces of Manitoba and Saskatchewan.

TABLE 1—DATA CONCERNING THE TOTAL NUMBER OF COLLECTIONS CULTURED FROM EACH PROVINCE DURING THE PERIOD 1925-1930.

| Provinces | Total number of collections cultured | Percentage of total number |
|---|---|---|
| Western Provinces | | |
| British Columbia | 4 | .4 |
| Alberta | 62 | 5.8 |
| Saskatchewan | 334 | 31.2 |
| Manitoba | 504 | 47.1 |
| Eastern Provinces | | |
| Ontario | 59 | 5.5 |
| Quebec | 36 | 3.4 |
| New Brunswick | 23 | 2.2 |
| Nova Scotia | 39 | 3.7 |
| Prince Edward Island | 9 | .8 |
| Total number | 1070 | |
| Western Provinces | 904 | 84.5 |
| Eastern Provinces | 166 | 15.5 |

During the period 1925-1930, nine physiologic forms of *P. graminis avenae* were isolated from the collections of oat stem rust made in Canada. The identification of these physiologic forms was not carried out under controlled environmental conditions. The mean types of infection produced by the nine physiologic forms on the differential hosts are shown in Table 2, and are illustrated by photographs in Plates I - III.

The frequency of occurrence of the different physiologic forms varied greatly, as determined by the number of isolations which were made of each form. Forms 1, 2 and 5 were most prevalent each year, as well as during the whole six-year period 1925-1930. During this period, 1257 isolations were made. Of this number 1213 isolations, or 96.5% consisted of forms 1, 2 and 5. The extreme frequency of isolation, particularly of forms 2 and 5, as compared with that of the other physiologic forms, is shown graphically in Text Figure 3. Forms 3, 4, 6, 7, 8 and 9 were isolated but rarely, a result indicating a limited occurrence of these particular physiologic forms of *P. graminis avenae* in Canada. These physiologic forms are more virulent than the commonly occurring forms 1, 2 and 5. In Table 3 is shown the total number of isolations of each physiologic form as well as the total number of isolations of physiologic forms, made from collections obtained from the different provinces during the period 1925 - 1930.

TABLE 2.—THE MEAN TYPES OF INFECTION PRODUCED BY THE NINE PHYSIOLOGIC FORMS ON THE DIFFERENTIAL HOSTS.

| Physiologic forms | Control host | Differential hosts | | |
|---|---|---|---|---|
| | Victory | White Russian | Richland, Heigira Strain Monarch Strain | Joanette Strain Strain 703 |
| 1 | 4 | 3–c | 2 | 1 |
| 2 | 4 | 3–c | 2 | 4 |
| 3 | 4 | 4 | 2 | 1 |
| 4 | 4 | 4 | 4 | 1 |
| 5 | 4 | 3–c | 2 | X |
| 6 | 4 | 4 | 4 | 4 |
| 7 | 4 | 4 | 2 | 4 |
| 8 | 4 | 3–c | 4 | 4 |
| 9 | 4 | 3–c | 3–c | 4 |

TABLE 3—DATA CONCERNING THE NUMBER OF ISOLATIONS OF PHYSIOLOGIC FORMS MADE DURING THE PERIOD 1925-1930

| Provinces | Physiologic forms | | | | | | | | | Total isolations by provinces |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | |
| British Columbia | – | 4 | – | – | 2 | – | – | – | – | 6 |
| Alberta | 4 | 30 | – | – | 41 | – | – | – | – | 75 |
| Saskatchewan | 18 | 161 | 2 | 4 | 204 | 1 | – | – | – | 390 |
| Manitoba | 40 | 267 | 5 | 5 | 259 | 6 | 6 | 1 | – | 589 |
| Ontario | 2 | 36 | 1 | 2 | 26 | – | 6 | – | – | 73 |
| Quebec | 5 | 18 | – | – | 19 | – | 1 | – | – | 43 |
| New Brunswick | 1 | 9 | – | – | 19 | – | – | – | – | 29 |
| Nova Scotia | 4 | 11 | – | – | 24 | – | 1 | 1 | 1 | 42 |
| Prince Edward Island | 1 | 1 | – | 1 | 7 | – | – | – | – | 10 |
| Total isolations by forms | 75 | 537 | 8 | 12 | 601 | 7 | 14 | 2 | 1 | 1,257 |

Physiologic specialization of *P. graminis avenae* in Canada does not appear to be extensive, if one is permitted to judge from the limited number of physiologic forms isolated during the period 1925-1930. From the standpoint of the production of a desirable stem rust resistant variety of oats, it does not seem at present to be a serious factor. Sufficient resistance to forms 1, 2 and 5, the most prevalent physiologic forms, is available in the differential hosts, Richland, Heigira Strain and Monarch Strain (Table 2). These hosts are also quite resistant to forms 3 and 7, as well as being moderately resistant to form 9. Such forms as 4, 6 and 8, which are capable of infecting heavily these hosts, have occurred but rarely during the period 1925-1930. However, it is possible that these forms may become more common in the future. It is of interest to note that only forms 3, 4, 6, 7 and 8 were isolated by Tedin (*51*) from collections of oat stem rust made in Sweden, all of which are more virulent than those forms commonly occurring in Canada.

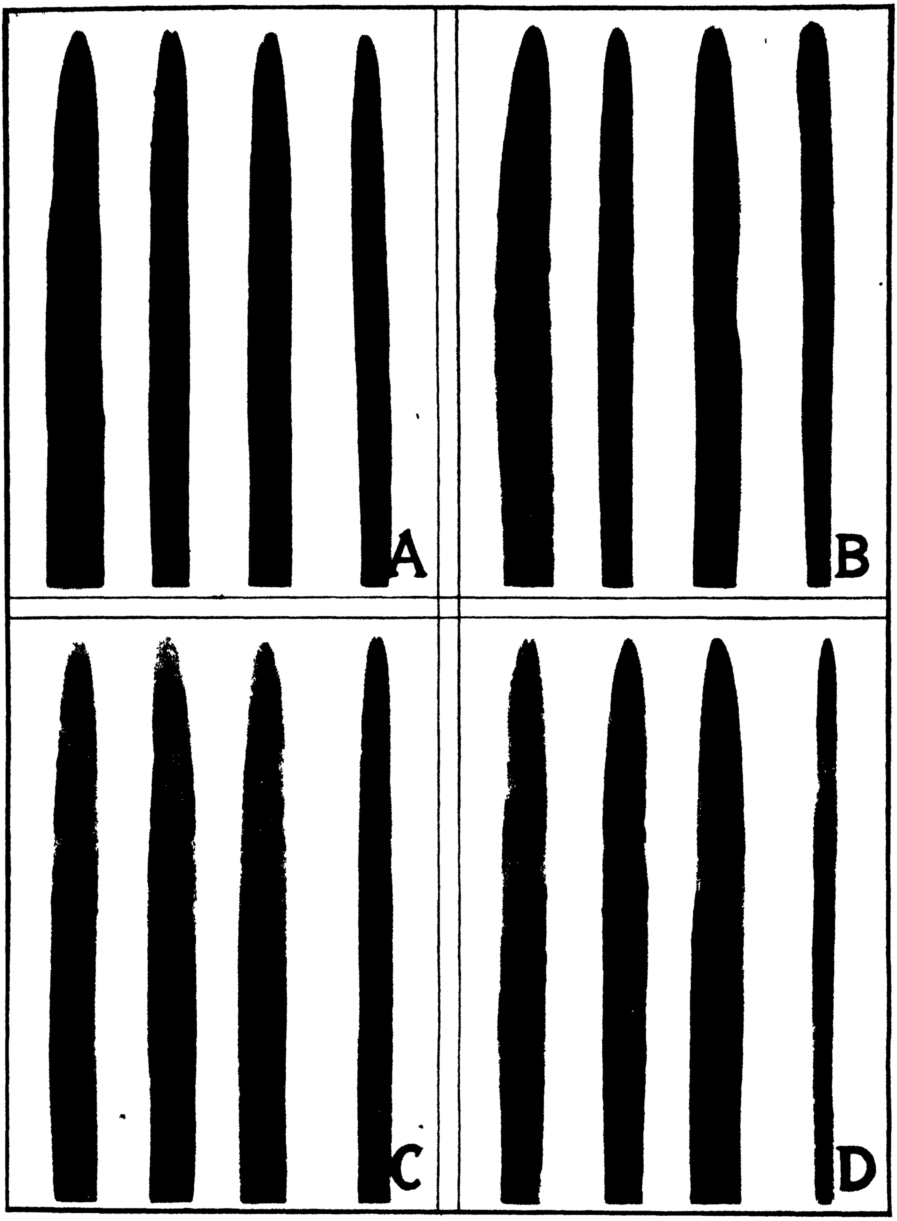


PLATE I

Figure A. The types of uredinial infection produced by *P. graminis avenae*, form 1, on four hosts in the seedling stage. Left to right. One leaf of Victory, White Russian, Richland and Joanette Strain.

Figure B. The types of uredinial infection produced by *P. graminis avenae*, form 2, on four hosts in the seedling stage. Left to right: One leaf of Victory, White Russian, Richland and Joanette Strain

Figure C. The types of uredinial infection produced by *P. graminis avenae*, form 3, on four hosts in the seedling stage. Left to right: One leaf of Victory, White Russian, Richland and Joanette Strain

Figure D. The types of uredinial infection produced by *P. graminis avenae*, form 4, on four hosts in the seedling stage. Left to right: One leaf of Victory, White Russian, Richland and Joanette Strain.

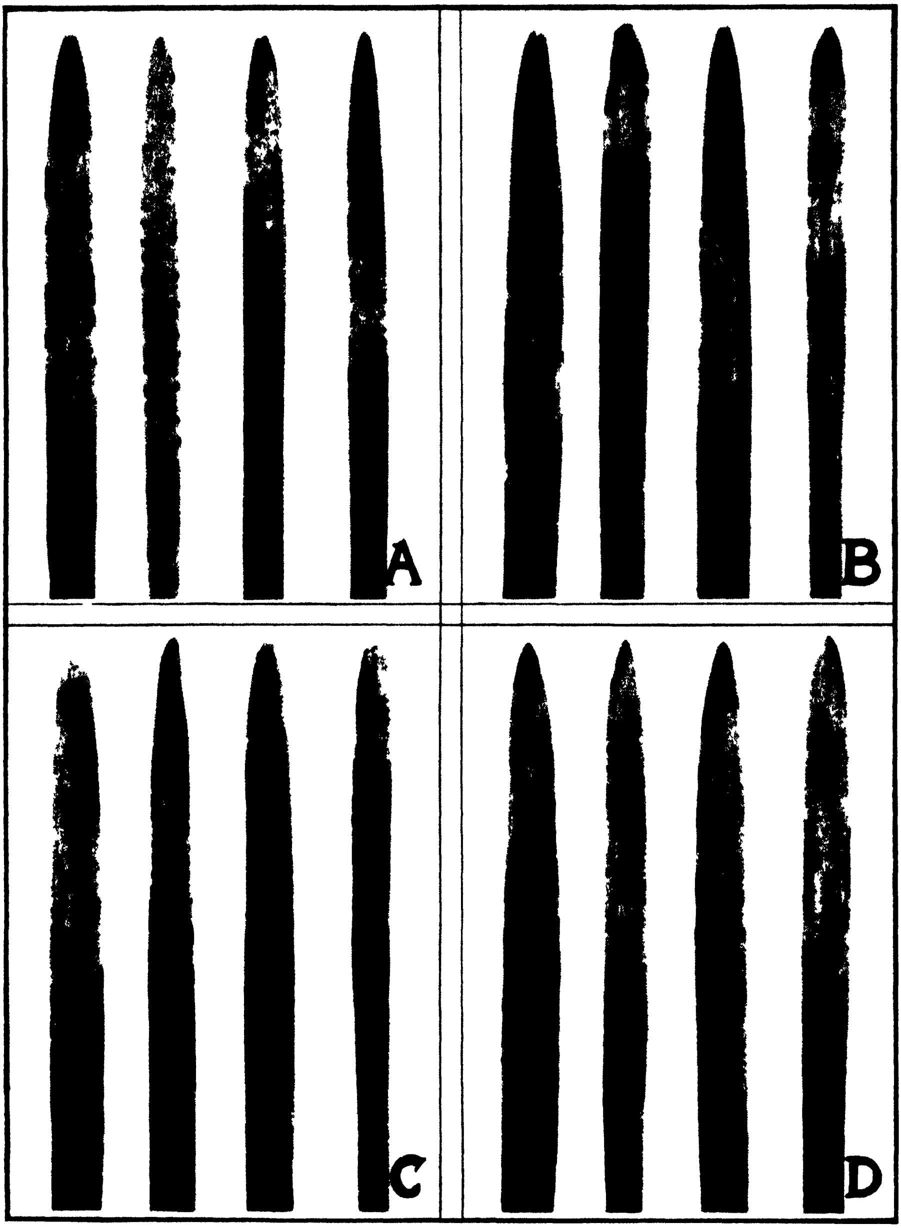


PLATE II.

Figure A. The types of uredinial infection produced by *P. graminis avenae*, form 5, on four hosts in the seedling stage Left to right: One leaf of Victory, White Russian, Richland and Joanette Strain.

Figure B. The types of uredinial infection produced by *P. graminis avenae*, form 6, on four hosts in the seedling stage. Left to right: One leaf of Victory, White Russian, Richland and Joanette Strain.

Figure C. The types of uredinial infection produced by *P. graminis avenae*, form 7, on four hosts in the seedling stage. Left to right: One leaf of Victory, White Russian, Richland and Joanette Strain.

Figure D. The types of uredinial infection produced by *P. graminis avenae*, form 8, on four hosts in the seedling stage. Left to right: One leaf of Victory, White Russian, Richland and Joanette Strain.

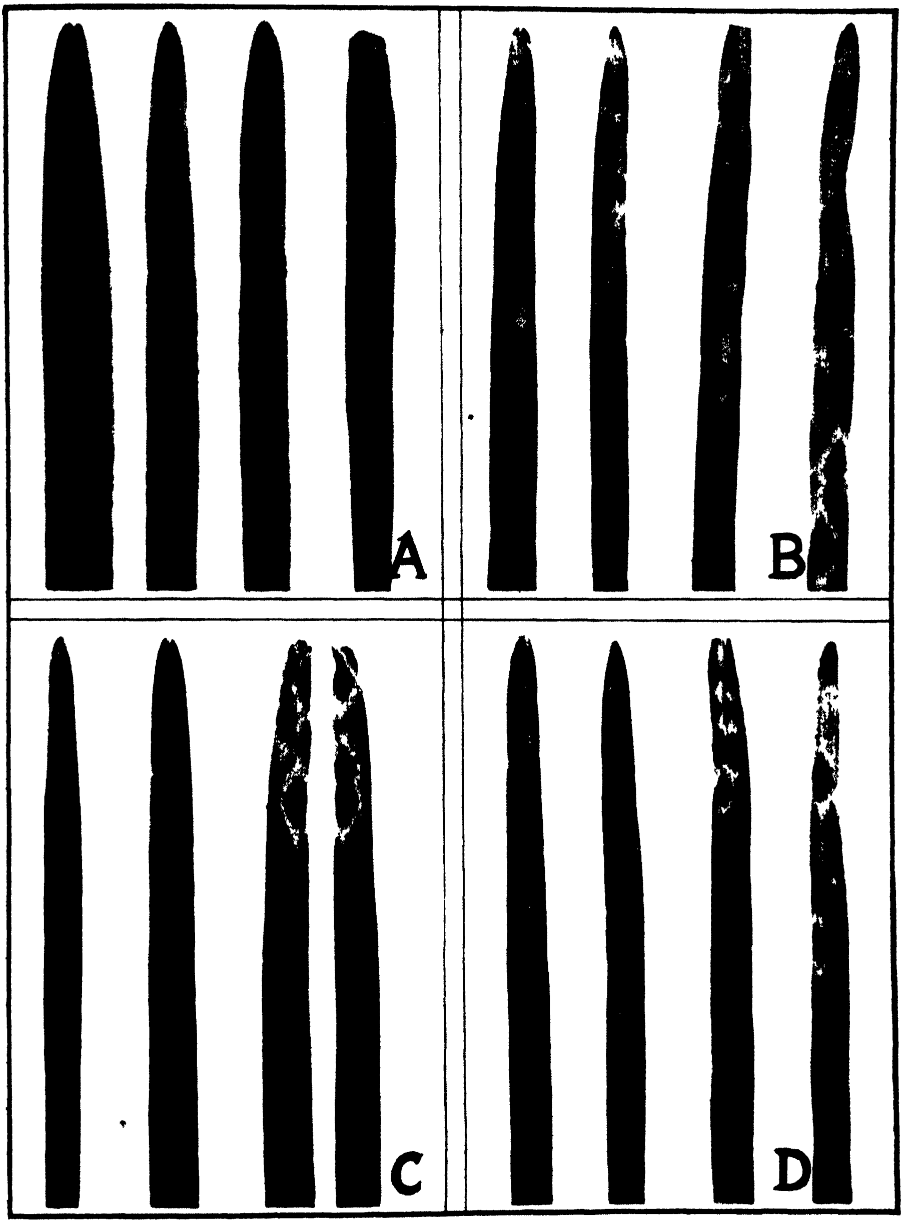


PLATE III

Figure A. The types of uredinial infection produced by *P. graminis avenae*, form 9, on four hosts in the seedling stage. Left to right: One leaf of Victory, White Russian, Richland and Joanette Strain.

Figure B. The types of uredinial infection produced by *P graminis avenae.* form 1, on Joanette Strain in the seedling stage when kept at four temperatures. Left to right: One leaf of Joanette Strain kept at temperatures of 12°, 16°, 24° and 28°C.

Figure C. The types of uredinial infection produced by *P. graminis avenae*, form 3, on Joanette Strain in the seedling stage when kept at four temperatures. Left to right: One leaf of Joanette Strain kept at temperatures of 12°, 16°, 24° and 28°C.

Figure D The types of uredinial infection produced by *P. graminis avenae*, form 4, on Joanette Strain in the seedling stage when kept at four temperatures. Left to right: One leaf of Joanette Strain kept at temperatures of 12°, 16°, 24° and 28°C.

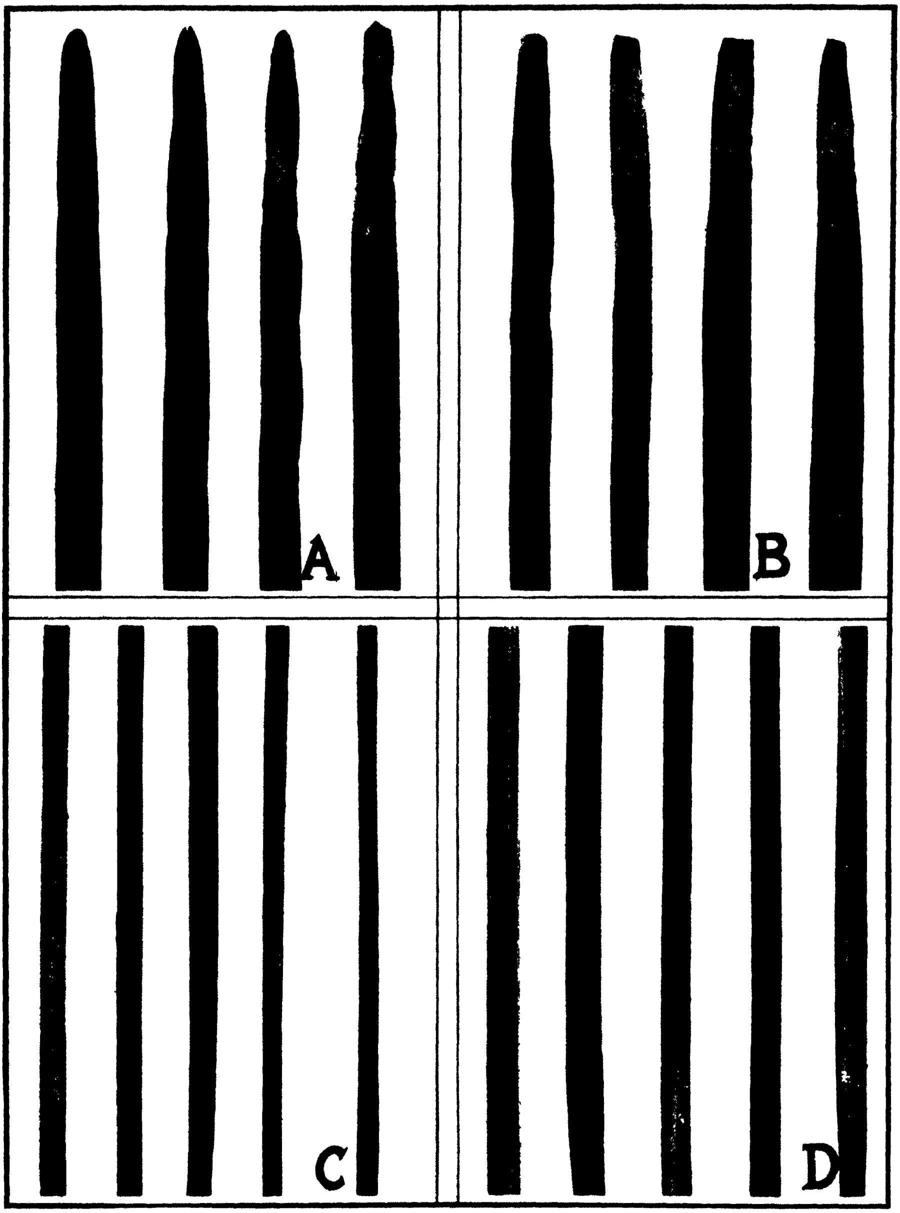


PLATE IV.

Figure A. The types of uredinial infection produced by *P. graminis avenae*, form 5, on Joanette Strain in the seedling stage when kept at four temperatures. Left to right: One leaf of Joanette Strain kept at temperatures of 12°, 16°, 24° and 28°C.

Figure B. The types of uredinial infection produced by *P. graminis avenae*, form 2, on Joanette Strain in the seedling stage when kept at four temperatures. Left to right. One leaf of Joanette Strain kept at temperatures of 12°, 16°, 24° and 28°C.

Figure C. The types of uredinial infection produced by *P. graminis avenae*, forms 1, 2, 3, 4 and 5, on Joanette Strain in the mature stage when kept at a temperature of 12°C. Left to right: One stem of Joanette Strain infected by forms 1, 2, 3, 4 and 5, respectively.

Figure D. The types of uredinial infection produced by *P. graminis avenae*, forms 1, 2, 3, 4 and 5, on Joanette Strain in the mature stage when kept at a temperature of 16°C. Left to right: One stem of Joanette Strain infected by forms 1, 2, 3, 4 and 5, respectively.

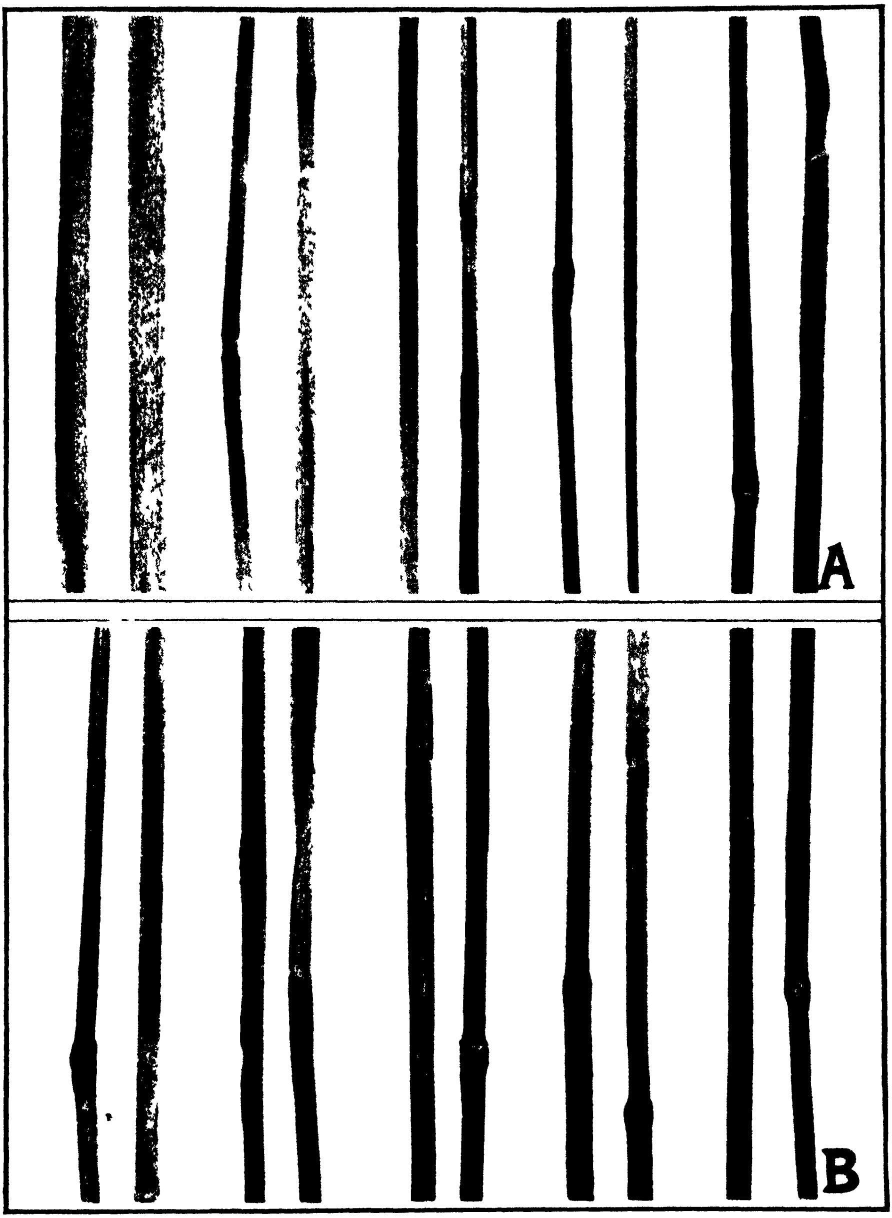


PLATE V.

Figure A The types of uredinial infection produced by *P. graminis avenae*, forms 1, 2, 3, 4 and 5, on Joanette Strain in the mature stage when kept at a temperature of 24°C Left to right Two stems of Joanette Strain infected by forms 1, 2, 3, 4 and 5, respectively

Figure B. The types of uredinial infection produced by *P. graminis avenae*, forms 1, 2, 3, 4 and 5, on Joanette Strain in the mature stage when kept at a temperature of 28°C. Left to right Two stems of Joanette Strain infected by forms 1, 2, 3, 4 and 5, respectively.

## EXPERIMENTAL METHODS AND MATERIALS

The methods employed in the study of the relation of environment to the uredinial and telial development of the physiologic forms varied according to the object of the individual experiments. The more general methods used will be stated here, while those of a more specific nature will be given in connection with the different experiments.

The nine physiologic forms of *P. graminis avenae* employed in the various experiments were isolated from collections of oat stem rust made in Canada during the period 1925-1930 (Table 3). The types of infection produced by the nine forms on the hosts, Victory, White Russian, Richland and Joanette Strain, in the seedling stage, are illustrated in Plates I - III. In certain experiments cultures of forms 6 and 7, yellow in colour, were also used. The colour of these cultures, according to Ridgway's Colour Standards (40, Plate 15), is "ochraceous orange", while that of normal oat stem rust (40, Plate 3), is "amber brown". These two cultures will be referred to as 6Y and 7Y. They were obtained from a barberry which had been artificially inoculated in the spring of 1931 with teliospore material which had been gathered from the field plots at Winnipeg, Man., during the autumn of 1930.

One or more of the hosts, Victory, White Russian, Richland and Joanette Strain, were used throughout the study. Victory is susceptible to all the forms, while the other hosts are differential in their reaction. These varieties of oats were employed first by Bailey (*1*) in studies on physiologic specialization in *P. graminis avenae*.

The classes of host reaction as well as the infection types employed by Bailey (*1*) were adopted. These are given in Table 4.

TABLE 4 —CLASSES OF HOST REACTION AND TYPES OF RUST INFECTION

| Classes of Host Reaction | Types of Rust Infection |
|---|---|
| Practically immune. | 0 No uredinia developed, but sharply defined hypersensitive flecks present. |
| Extremely resistant. | 1. Infection very light; uredinia minute, scattered, and surrounded by sharply defined necrotic areas. |
| Moderately resistant. | 2. Infection light; uredinia usually small and scattered, hypersensitive areas varying from sharply defined necrosis to pronounced chlorosis. |
| Moderately susceptible. | 3. Infection moderate; uredinia mid-sized with a tendency to coalesce; true hypersensitiveness absent, but more or less well marked chlorosis present. |
| Completely susceptible. | 4. Infection normal and heavy; uredinia large, numerous and confluent, hypersensitiveness absent, but chlorosis may be present. |
| Indeterminate. | X. Uredinia very variable, apparently including all types of infection, often on the same leaf blade; no mechanical separation of the types seems possible, and the infection is ill-defined and heterogeneous. |

The symbols (=), (−), (±), and (+) indicate quantitative variations in the types of uredinial infection. A semicolon (;) when used indicates the presence of flecks. The letters (cn) denote that hypersensitiveness ranging from chlorosis to necrosis accompanies the infection.

TABLE 5.—THE TYPES OF UREDINIAL INFECTION PRODUCED BY SEVEN PHYSIOLOGIC FORMS ON SEEDLINGS OF FOUR HOSTS KEPT AT TWO TEMPERATURES.

| Forms | Hosts | Temperatures | | | | | |
|---|---|---|---|---|---|---|---|
| | | 14°C. | | | 26°C. | | |
| | | Trial 1 | Trial 2 | Trial 3 | Trial 1 | Trial 2 | Trial 3 |
| 1 | Victory | 11/11(4) | 16/16(4) | 13/13(4)± | 10/10(4)+ | 10/10(4)± | 10/10(4)+ |
| | White Russian | 11/11(3)c̄ | 10/10(3)c̄ | 10/10(3)c̄ | 12/12(3)c̄ | 12/12(3)c̄n | 16/16(3)c̄ |
| | Richland | 13/13(2)= | 14/14(2)= | 14/14(2) | 13/13(2)- | 10/10(2)- | 14/14(2)- |
| | Joanette Strain | $\frac{8(1)-;\ 3}{12}$ | $\frac{9(1)=\ 1(x)=}{10}$ | $\frac{9(1)-;\ 4}{13}$ | 11/11(4) | $\frac{6(4)-14(3)\overset{+}{c}n}{20}$ | 12/12(4)$\overset{\pm}{c}$ |
| 2 | Victory | 12/12(4) | 11/11(4)- | 11/11(4)+ | 15/15(4)+ | 10/10(4)+ | 13/13(4) |
| | White Russian | 7/7(3)c̄ | 10/10(3)c̄ | 13/13(3)c̄ | 13/13(3)c̄ | 19/19(3)c̄ | 11/11(3)c̄ |
| | Richland | 9/9(2)= | 10/10(2)- | 15/15(2) | 8/8(2)- | 9/9(2) | 12/12(2)- |
| | Joanette Strain | 12/12(4) | 10/10(4) | 10/10(4) | 9/9(4)+ | 12/12(4)+ | 10/10(4)- |
| 3 | Victory | 9/9(4) | 10/10(4) | 11/11(4)+ | 14/14(4)+ | 10/10(4)+ | 10/10(4) |
| | White Russian | 7/7(4) | 10/10(4) | 18/18(4) | 11/11(4) | 10/10(4) | 10/10(4) |
| | Richland | 11/11(2)- | 10/10(2)- | 22/22(2) | 13/13(2)- | 10/10(2)- | 13/13(2)- |
| | Joanette Strain | $\frac{10(1)=;\ 7}{17}$ | $\frac{3(1)=;\ 6}{10}$ | 10/10(1)= | 14/14(4)$\overset{\pm}{c}$ | 10/10(4)c̄ | 12/12(4)c̄n |
| 4 | Victory | 13/13(4) | 10/10(4)± | 10/10(4)+ | 12/12(4)+ | 10/(10)± | 10/10(4)+ |
| | White Russian | 11/11(4) | 8/8(4)± | 19/19(4) | 14/14(4) | 10/10(4)± | 10/10(4)- |
| | Richland | 9/9(4) | 8/8(4)± | 14/14(4) | 10/10(4)+ | 10/10(4)± | 17/17(4)± |
| | Joanette Strain | $\frac{1(x)=8(1)\pm}{9}$ | 10/10(1)- | $\frac{2(x)=8(1)-}{10}$ | 14/14(4)± | 10/10(4)c | 10/10(4)c̄n |
| 5 | Victory | 14/14(4) | 13/13(4) | 13/13(4) | 16/16(4)± | 11/11(4)- | 12/12(4) |
| | White Russian | 13/13(3)$\overset{=}{c}$ | 12/12(3)c | 10/10(3)c | 16/16(3)$\overset{=}{c}$ | 18/18(3)c | 12/12(3)c |
| | Richland | 19/19(2)= | 14/14(2)- | 10/10(2) | 15/15(2)- | 15/15(2)- | 11/11(2)- |
| | Joanette Strain | $\frac{12(1)\pm 1(x)-}{13}$ | $\frac{7(1)-3(x)=}{10}$ | $\frac{9(1)-2(x)-;}{11}$ | 11/11(4)- | 15/15(4)c | 12/12(4)c̄ |
| 6 | Victory | 7/7(4) | 8/8(4)± | 10/10(4)+ | 14/14(4)+ | 12/12(4)± | 12/12(4)± |
| | White Russian | 8/8(4) | 10/10(4) | 13/13(4) | 13/13(4) | 14/14(4) | 10/10(4) |
| | Richland | 11/11(4) | 15/15(4)+ | 10/10(4)+ | 10/10(4)+ | 16/16(4)± | 16/16(4)± |
| | Joanette Strain | 8/8(4)c̄ | 12/12(4)c | 12/12(4)± | 12/12(4)+ | 15/15(4) | 12/12(4) |
| 7 | Victory | 13/13(4) | 16/16(4)± | 10/10(4)± | 12/12(4) | 10/10(4)± | 11/11(4)+ |
| | White Russian | 10/10(4) | 17/17(4) | 16/16(4)± | 10/10(4)- | 10/10(4) | 15/15(4) |
| | Richland | 9/9(2)- | 16/16(2)- | 10/10(2)- | 9/9(2)= | 11/11(2)= | 10/10(2) |
| | Joanette Strain | 12/12(4) | 18/18(4)± | 12/12(4)± | 19/19(4)- | 13/13(4)± | 14/14(4)+ |

The method of recording results of inoculations is as follows. The types of infection are enclosed in brackets. The figures preceding the types of infection indicate the number of plants infected, e.g., 8/10(4)– shows that eight out of ten plants inoculated became infected and the type of infection produced on them was (4)–. A record of inoculation, such as $\frac{2(1)\ 3(2)\ ;\,5}{10}$, indicates that out of ten plants inoculated, the (1) type of infection was produced on two plants; the (2) type on three plants; and the ; 5 shows that only flecks occurred on five plants.

For the inoculation of the plants, a standard procedure was followed throughout this study. After thoroughly washing the hands, the bloom was removed from the leaves, or stems, of the plants by rubbing them lightly. The plants were then sprayed with water by means of an atomizer, and urediniospores of the desired physiologic form were applied with the thumb and forefinger. The hands were again thoroughly washed before another physiologic form was used. This method of applying the urediniospores to the plants, instead of using an inoculating needle of the type generally used in rust culture work, had the advantage of greater speed and was equally as efficient as the other.

After inoculation, the pots of plants were labelled and placed in incubation chambers for a period of 48 hours to allow infection to take place. The incubation chambers consist essentially of a galvanized iron cylinder with a glass top which stands inside a galvanized iron tray having a shallow rim. Water placed in the tray keeps the atmospheric humidity sufficiently high in the chamber to permit excellent infection. At Madison, the inoculated plants were kept for 48 hours in large incubation chambers in which the atmospheric humidity and temperature could be controlled. In the studies carried on at Winnipeg, after the pots of plants were kept for 48 hours in the incubation chambers, they were removed and placed on benches in the desired sections of a greenhouse. The space on the benches was divided into compartments by glass partitions.

In the various studies upon the effect of temperature on the uredinial and telial development of the physiologic forms the experimental conditions were as follows. At Winnipeg, two sections of a greenhouse were equipped with temperature control apparatus. One section was maintained at a relatively low, the other at a relatively high temperature. In both sections, fluctuations from the mean temperature were limited to approximately 2°C. Temperature was the only environmental factor under control in these sections of the greenhouse. The conditions of light, atmospheric humidity, etc., were subject to considerable variation but were essentially the same in both sections. Artificial lighting, when found to be desirable, was available in both sections to supplement daylight. At Madison, the various studies were carried on in four glass chambers in which the atmospheric humidity, as well as the temperature was controlled. The four chambers were located in separate sections of a greenhouse in which the temperature could also be regulated. The chambers were maintained at temperatures of 12°, 16°, 24°

and 28°C. In the studies dealing with temperature, the relative atmospheric humidity was maintained at 75% in the different chambers. Artificial lighting, when necessary, was used in the four chambers to supplement daylight.

The various experiments carried on at Winnipeg, or at Madison, will be designated accordingly.

## The Relation of Temperature to the Uredinial and Telial Development of the Physiologic Forms

### EFFECT OF TEMPERATURE ON UREDINIAL DEVELOPMENT

### REVIEW OF LITERATURE

That temperature influences the development of cereal rusts has been observed by numerous workers (3, 8, 9, 17, 20, 26, 29, 44, 52, 53). Their observations or investigations dealt largely, however, with the effect of temperature on the germination of the urediniospores and on the duration of the incubation period. The effect of the environment upon the later uredinial development has been investigated also. Gassner (*12*) found that in South America the various cereal rusts were affected differently by environmental conditions. New uredinial infections by *Puccinia triticina* Erikss. and *Puccinia coronifera* Kleb. occurred at all seasons of the year, while infections by *Puccinia graminis* Pers. appeared to be more or less limited to early summer and autumn. Temperature, as a variable factor of the environment, may be considered to have had some influence on the spread of the rusts. Stakman and Lambert (*46*), in considering the causes of stem rust epidemics in the spring wheat area of the United States, expressed the opinion that temperature is one of the important variables in the environment which determines whether or not epidemics will develop. The results of their investigations showed that there was a tendency for destructive epidemics to develop in warm growing seasons and for relatively light infection to occur in cool seasons.

The identification and separation of physiologic forms in the cereal rusts is based upon the types of uredinial infection produced by the different forms on a number of differential hosts. The reactions of these hosts to the various physiologic forms were considered to be practically constant. Although it was recognized that environmental conditions were capable of producing slight variations in the host reactions, it was not considered that these variations could be sufficiently marked to present any serious obstacle to the separation and identification of the various physiologic forms. As the result of a study of the constancy of host reactions to *Puccinia graminis tritici-compacti*, Stakman *et al.* (*43*) state, "The facts recorded in this paper, supported by experimental work in the rust nursery and by field investigations, indicate that rust resistance is comparable with other permanent characters, and that it is not primarily controlled by seasonal conditions, soil type, geographical location, or other cultural conditions. It is rather an hereditary character, which cannot be produced by the accumulation of fluctuating variations within a susceptible line, nor broken down by changes in the host or parasite". Peltier (*35*) also came to the conclusion from the results of a study of the effects of temperature upon host reactions to *P.*

*graminis tritici*, forms 3 and 9, that the host reactions were not appreciably influenced by the environmental factor, temperature. In other words, the infection types produced by these physiologic forms on a number of hosts were not significantly different at various temperatures. However, the fact that environmental conditions are capable of inducing striking changes in the reactions of differential hosts to physiologic forms of different cereal rusts has been clearly demonstrated in recent years.

Waterhouse (*54*), in 1929, found that variations in environmental conditions in the greenhouse influenced profoundly the reactions of differential hosts to various rusts. In the case of *P. graminis tritici*, there was a change from complete susceptibility of certain hosts in the hotter months to complete resistance in the cooler months of the year. The reactions of several differential hosts showed this change. Some physiologic forms showed more striking alterations of this nature than others. Observations on three physiologic forms of *P. graminis avenae* revealed the same situation. When the temperature in the greenhouse was high, one of the differential hosts, Joanette Strain, was completely susceptible to form 1; when low, it was completely resistant. Only this differential host showed a change in reaction due to a change in temperature. The types of infection produced by forms 2 and 7 on all differential hosts, however, were not significantly changed. Essentially similar results were obtained with *P. triticina* and *P. simplex* (Korn.) Erikss. and Henn., that is, some hosts were susceptible at a high temperature while at a low tenperature they were resistant. The significance of these results to studies of physiologic forms in the cereal rusts has led to further investigations of the problem by other workers.

In 1930, Gordon (*15*) reported the results of a preliminary study on the effect of temperature upon host reactions to eight physiologic forms of *P. graminis avenae*. This study was carried out in sections of a greenhouse which were maintained at approximately constant temperatures. The results obtained showed that the reaction of the differential host, Joanette Strain to forms 1, 3, 4 and 5 at a low (57.4°F.) and at a high temperature (75.4°F.) were strikingly different. This host was susceptible to forms 1, 3, 4, and 5 at the high temperature but was resistant to forms 1, 3 and 4, and indeterminate in its reaction to form 5, at the low temperature. There was no significant difference in the reactions of the hosts Victory, White Russian and Richland to these forms when kept at different temperatures. The types of infection produced by forms 2, 6, 7 and 8 on the four hosts, Victory, White Russian, Richland and Joanette Strain, were not affected by different temperatures.

Peturson (*36*), in 1930, first showed that temperature influenced the types of infection produced by physiologic forms of *Puccinia coronata avenae* (Corda) Erikss. and Henn. on certain differential hosts. One host, Red Rustproof, was susceptible to form 4 at temperatures of 70° and 77°F., but resistant at 57°F. All the differential hosts were susceptible to form 7 at a temperature of 77°F. but some were resistant at 57°F. The types of infection produced by forms 1 and 3 on all hosts were not influenced by differences in temperature.

In 1931, Gassner and Straib (*13*) reported the results of their investigation on the effect of temperature on the constancy of the infection types produced by *P. triticina* on a number of wheat varieties generally considered to be very resistant. A definite increase in the susceptibility of certain varieties occurred at the lowest temperature employed (6°C.).

Johnson (*24*) studied the behaviour of several physiologic forms of *P. graminis tritici* characterized by the (X), or heterogeneous, type of infection on certain wheat varieties at low (55° - 60°F.) and high temperatures (70° - 75°F.). The behaviour of these forms on hosts which were normally indeterminate in their reaction was strikingly different at the two temperatures. The (X) type of infection did not appear at either of these temperatures. At the low temperature, the hosts were highly resistant, and, at the high temperature, they were quite susceptible.

Newton *et al* (*32*) found that low temperatures appear to favour the optimum development of the uredinial stage of *P. glumarum*. At a temperature of 64°F., such varieties as Chul, Mindum and Kanred were highly susceptible and abundant pustules were developed on them, while at 70°F. they became highly resistant, only flecks being produced.

In Germany, Hey (*19*) determined the types of uredinial infection produced by eight physiologic forms of *P. simplex* on ten standard varieties of barley at temperatures of 10°, 18°. 25° and 30°C. Significant differences in the types of uredinial infection produced by some forms on certain varieties were found to occur at the different temperatures.

Melander (*30*) found that form 35 of *P. graminis tritici* produced only minute uredinia on Little Club wheat after it was kept fifty-nine days at a temperature of 0 - 1°C.

The effect of temperature on the expression of factors governing rust reaction in a cross between Marquillo and Marquis wheat was reported by Harrington (*16*) in 1931. Two random populations of $F_2$ plants of this cross were tested for the reaction of their $F_3$ seedling progenies to form 21 of *P. graminis tritici* in the greenhouse at average daily temperatures of 69.7° for one population, and 60.6°F. for the other. At 69.7°F. ten families of a total of 781 were resistant; at 60.6°F. five families of a total of 301 were susceptible.

### THE UREDINIAL DEVELOPMENT OF SEVEN PHYSIOLOGIC FORMS AT TWO TEMPERATURES (WINNIPEG)

The object of this experiment was to determine the effect of temperature upon the uredinial development of physiologic forms 1, 2, 3, 4, 5, 6 and 7, on the hosts, Victory, White Russian, Richland and Joanette Strain. The classification of the forms mentioned is based upon the types of infection which they produce on the hosts White Russian, Richland and Joanette Strain (Table 2). If these infection types are capable of being altered by temperature, it is obvious that errors in identification are liable to occur.

The procedure followed during each of three trials was to inoculate two sets of seedlings of the hosts mentioned with urediniospores of each physiologic form. Prior to inoculation, the hosts were grown in the greenhouse under the same environmental conditions. After being kept for 48 hours following inoculation in the incubation chambers, one set of hosts was placed in each of the temperature-controlled sections of the greenhouse until observations on the complete uredinial development of the different forms were recorded. One section of the greenhouse was maintained at a low (14°C.), the other ay a high temperature (26°C.).

The first effect of temperature upon the uredinial development of the various forms to be observed was that, while the incubation period at 26°C. was 7 days, at 14°C. it was extended to 12 days.

The types of uredinial infection produced by the seven physiologic forms on the four hosts kept at 14°C. and at a temperature of 26°C., are shown in Table 5. There was no significant difference in the types of infection produced by forms 2, 6 and 7 on any of the hosts at the two temperatures. Temperature apparently did not influence the complete uredinial development of these forms on the hosts used. However, the complete uredinial development of forms 1, 3, 4, and 5 was strikingly different on the differential host Joanette Strain, at the low and high temperatures, but was not appreciably different on the other hosts. Joanette Strain was quite susceptible to these four forms at 26°C. but much more resistant at a temperature of 14°C. The high temperature apparently favoured the uredinial development of these forms on Joanette Strain, while the low temperature inhibited their growth.

This preliminary experiment on the effect of temperature upon the uredinial development of the physiologic forms was carried on during February, 1931. At this time only seven physiologic forms were available for study. All the known physiologic forms of *P. graminis avenae* were used in a much more extensive experiment carried on at Madison during the autumn of 1931.

## THE UREDINIAL DEVELOPMENT OF NINE PHYSIOLOGIC FORMS AT FOUR TEMPERATURES (MADISON)

In this experiment, the nine physiologic forms known to occur in *P. graminis avenae* were available for study. Forms 6Y and 7Y, yellow in colour, were also included. The uredinial development of all the forms on the hosts Victory, White Russian, Richland and Joanette Strain was determined at temperatures of 12°, 16°, 24° and 28°C. The procedure followed during each of three trials was to inoculate the eight sets of the hosts in the seedling stage with urediniospores of each physiologic form. Prior to inoculation the hosts were grown under the same environmental conditions. Two sets of the hosts inoculated with each form were placed in temerature-controlled chambers maintained at temperatures of 12°, 16°, 24° and 28°C. The hosts were kept in the chambers during the complete development of the uredinial stage of the various physiologic forms.

The development of the hosts was markedly different at the low (12° and 16°C.) and at the high temperatures (24° and 28°C.). At 12° and 16°C., the plants grew slowly but were quite healthy in appearance, while at temperatures of 24° and 28°C., particularly at 28°C., it was quite evident that the environmental conditions were distinctly unfavourable for their growth. Practically all plants showed considerable chlorosis and some died before the complete development of the uredinia upon them could be attained.

TABLE 6.—THE TYPES OF UREDINIAL INFECTION PRODUCED BY NINE PHYSIOLOGIC FORMS ON SEEDLINGS OF FOUR HOSTS KEPT AT FOUR TEMPERATURES.

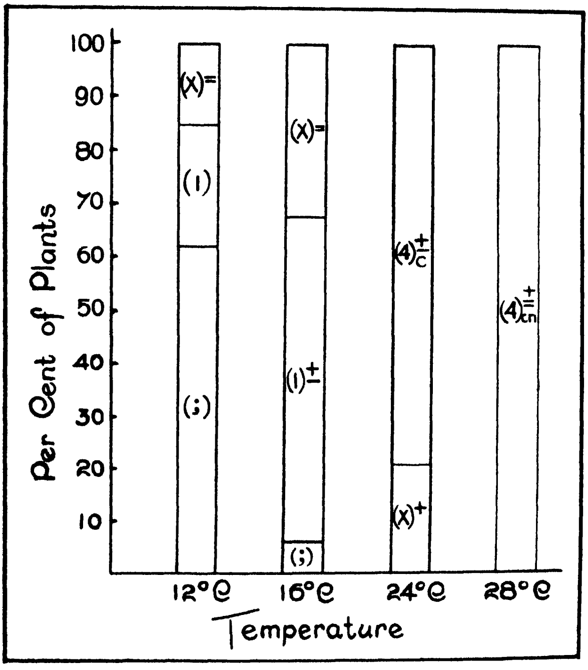
| Forms | Hosts | Tenperatures | | | |
|---|---|---|---|---|---|
| | | 12°C. | 16°C. | 24°C. | 28°C. |
| 1 | Victory | 70/70(4)- | 69/69(4)± | 72/73(4)±c | 66/75(4)±cn |
| | White Russian | 87/87(3)=c | 80/80(3)-c | 83/88(3)-c | 67/80(3)-cn |
| | Richland | 70/70(2)- | 80/80(2)- | 87/88(2)- | 75/82(2)=cn |
| | Joanette Strain | $\frac{20(1)14(x)=;\ 56}{90}$ | $\frac{55(1)\pm 30(x)=;\ 6}{91}$ | $\frac{16(x)+61(4)\pm c}{80}$ | 86/94(4) $\underset{=}{+}$ cn |
| 2 | Victory | 64/64(4) | 70/70(4)± | 61/61(4)c | 73/77(4)±cn |
| | White Russian | 62/63(3)-c | 74/75(3)-c | 58/62(3)-c | 66/78(3)=cn |
| | Richland | 79/80(2)- | 66/66(2)- | 54/57(2)- | 64/79(2)-cn |
| | Joanette Strain | 66/66(4)-c | 79/81(4)± | 74/75(4)c | 67/74(4)±cn |
| 3 | Victory | 84/84(4)- | 73/73(4) | 62/68(4)c | 63/70(4) $\underset{=}{+}$ cn |
| | White Russian | 90/92(4)- | 79/80(4) | 64/65(4)±c | 69/75(4) $\underset{=}{+}$ cn |
| | Richland | 80/83(2)- | 62/66(2) | 83/90(2)-c | 61/73(2)=cn |
| | Joanette Strain | $\frac{11(1)\pm;\ 82}{95}$ | $\frac{37(1)\pm 6(x)=;\ 38}{81}$ | $\frac{9(x)+82(4)c}{94}$ | 67/77(4) $\underset{=}{+}$ cn |
| 4 | Victory | 70/70(4)- | 60/60(4) | 61/64(4)±cn | 68/79(4)±cn |
| | White Russian | 52/52(4)- | 75/77(4) | 58/61(4)c | 69/79(4) $\underset{=}{+}$ cn |
| | Richland | 77/79(4)- | 80/81(4) | 81/83(4)±c | 70/79(4)±cn |
| | Joanette Strain | $\frac{14(1)\pm 6(x)=;\ 54}{78}$ | $\frac{48(1)\pm 17(x)=;14}{80}$ | $\frac{9(x)+71(4)c}{80}$ | 67/79(4)±cn |
| 5 | Victory | 75/75(4)- | 75/75(4)± | 82/82(4)±cn | 75/82(4) $\underset{=}{+}$ cn |
| | White Russian | 77/84(3)-c | 82/83(3)-c | 81/84(3)-c | 70/79(3)=cn |
| | Richland | 81/82(2)- | 75/78(2)- | 86/88(2)-cn | 69/81(2)=cn |
| | Joanette Strain | $\frac{34(1)\pm 12(x)=;45}{95}$ | $\frac{46(1)32(x)-;\ 3}{81}$ | $\frac{20(x)+c62(4)\pm c}{87}$ | 72/84(4) $\underset{=}{+}$ cn |
| 6 | Victory | 55/55(4)- | 47/50(4) | 39/40(4)c | 55/58(4)±cn |
| | White Russian | 50/51(4)- | 53/54(4)- | 42/42(4)-c | 46/53(4) $\underset{=}{+}$ cn |
| | Richland | 53/54(4) | 53/54(4) | 40/41(4) | 46/55(4)±cn |
| | Joanette Strain | 58/59(4)- | 50/50(4) | 52/52(4)c | 48/52(4) $\underset{=}{+}$ cn |

TABLE 6.—*Continued*

| Forms | Hosts | Temperatures | | | |
|---|---|---|---|---|---|
| | | 12°C. | 16°C. | 24°C. | 28°C. |
| 7 | Victory | 43/43(4)- | 56/56(4) | 45/45(4)c | 43/51(4) ± cn |
| | White Russian | 53/53(4)- | 54/55(4) | 48/51(4)c | 44/53(4) $\underset{=}{+}$cn |
| | Richland | 47/50(2)- | 50/51(2)- | 49/55(2)- | 43/52(2) = cn |
| | Joanette Strain | 53/55(4)- | 52/54(4) | 48/51(4) ± c | 44/51(4) ± cn |
| 8 | Victory | 46/48(4) | 47/47(4) | 51/53(4) ± c | 42/52(4) ± cn |
| | White Russian | 52/53(3) = c | 50/52(3)-c | 44/48(3)-c | 41/49(3) = cn |
| | Richland | 58/61(4) | 53/56(4) | 52/55(4)c | 43/48(4) $\underset{=}{+}$cn |
| | Joanette Strain | 55/56(4) | 47/47(4) | 51/52(4)c | 46/51(4) ± cn |
| 9 | Victory | 61/62(4)- | 54/54(4) | 45/47(4) ± c | 49/59(4) ± cn |
| | White Russian | 53/54(3)-c | 52/53(3)-c | 48/51(3)-c | 49/55(3)-cn |
| | Richland | 54/55(3)-c | 53/54(3)-c | 51/52(3)c | 43/51(3) ± cn |
| | Joanette Strain | 52/54(4)- | 54/54(4) | 54/56(4)c | 42/49(4) ± cn |
| 6Y | Victory | 50/50(4)- | 55/55(4) | 46/49(4) ± c | 44/53(4) ± cn |
| | White Russian | 49/49(4)- | 51/52(4)- | 46/50(4) ± c | 48/56(4) $\underset{=}{+}$cn |
| | Richland | 55/56(4) | 54/55(4) | 52/54(4) ± c | 54/62(4) ± cn |
| | Joanette Strain | 59/61(4)- | 52/54(4) | 56/59(4)c | 55/62(4) $\underset{=}{+}$cn |
| 7Y | Victory | 60/61(4) | 54/54(4) | 48/52(4) ± c | 43/55(4) ± cn |
| | White Russian | 57/58(4)- | 47/48(4) | 54/54(4) ± c | 53/59(4) $\underset{=}{+}$cn |
| | Richland | 54/56(2)- | 46/46(2)- | 51/58(2) = c | 40/56(2) ± cn |
| | Joanette Strain | 51/51(4) | 47/47(4) | 53/56(4) ± c | 49/56(4) ± cn |

The first effect of the different temperatures to be observed upon the uredinial development of the various forms was the difference in length of the incubation periods at the four temperatures. At 12°C., the length of the incubation period amounted to 16 days; at 16°C., 12 days; at 24°C., 8 days; and at 28°C., 9 days. The shortest period of incubation occurred at 24°C. It was greatly extended at the temperatures below, and slightly so at the temperatures above this one.

With regard to the complete development of the uredinial stage of the various forms at the four temperatures, it was again found that temperature profoundly influenced the development of certain forms. The complete uredinial development of the various physiologic forms at the four temperatures, as expressed by the types of infection produced by them on the different hosts, is shown in Table 6. Only minor variations occurred in the types of infection produced by forms 2, 6, 7, 8 and 9 on all the hosts at the four temperatures. Similarly, only slight variations were observed in the types of infection produced by forms 1, 3, 4 and 5 on Victory, White Russian and Richland at the different temperatures. However, the types of uredinial infection produced by these four forms on Joanette Strain were markedly changed by temperature. Photographs illustrating the types of uredinial infection produced by forms 1, 3, 4 and 5 on Joanette Strain are presented in Plates III and IV. The uredinial development of form 2 on this host is shown in Plate IV by way of comparison with that of forms 1, 3, 4 and 5. The uredinial development of this form on Joanette Strain at the four different temperatures is typical of the physiologic forms which are not appreciably affected by temperature.



Text Figure 4. A graph illustrating the percentage of seedlings of Joanette Strain on which the types of infection indicated were produced by form 1 at four temperatures. At 12°C., (;) were produced on approximately 60%, (1) on 25% and (x) = on 15% of the seedlings. At 16°C., (;) were produced on approximately 5%, (1) ± on 65% and (x) = on 30%. At 24°C., (x) + was produced on approximately 20% and (4) ± c on 80%. At 28°C., (4) ± cn was produced on 100% of the seedlings.

The most extensive uredinial development of forms 1, 3, 4 and 5 occured on Joanette Strain at 28°C., while the least was at a temperature of 12°C. Their uredinial development on this host at 16°C. was slightly greater than that at 12°C.,; at 24°C., it resembled quite closely that which occurred at 28°C. The difference in the uredinial development of form 1 on Joanette Strain at the four temperatures is shown graphically in Text Figure 4. The number of Plants on which each type of infection was produced is expressed as a percentage of the total number of infected plants. Similar differences in the uredinial development of forms 3, 4 and 5 on Joanette Strain occurred at the four temperatures.

Of the nine physiologic forms of *P. graminis avenae*, in only four of them, forms 1, 3, 4 and 5, did the uredinial development appear capable of being appreciably changed by temperature.

TABLE 7.—THE TYPES OF UREDINIAL INFECTION PRODUCED BY FORMS 1, 2, 3, 4, AND 5 ON SEEDLINGS OF FOUR HOSTS KEPT AT DIFFERENT TEMPERATURES.

| Forms | Hosts | Temperatures | |
|---|---|---|---|
| | | 12°C. before and 28°C. after inoculation | 12°C. before and after inoculation |
| 1 | Victory | 32/32(4) ± c | 31/31(4)– |
| | White Russian | 33/33(3)–c | 35/35(3)–c |
| | Richland | 33/34(2)– | 32/32(2)– |
| | Joanette Strain | 34/35(4) ± cn | $\frac{4(1)-;\ 30}{34}$ |
| 2 | Victory | 31/32(4) ± cn | 30/30(4)– |
| | White Russian | 32/32(3)–cn | 36/36(3)–c |
| | Richland | 31/33(2)– | 30/30(2)– |
| | Joanette Strain | 32/33(4) ± c | 31/31(4)– |
| 3 | Victory | 37/37(4) ± cn | 32/32(4)– |
| | White Russian | 33/33(4)c | 33/33(4)– |
| | Richland | 31/32(2)– | 31/31(2)– |
| | Joanette Strain | 32/33(4) ± cn | $\frac{2(1)-;\ 33}{35}$ |
| 4 | Victory | 31/31(4) ± c | 30/30(4)– |
| | White Russian | 33/34(4)cn | 31/31(4)– |
| | Richland | 37/37(4) ± cn | 32/33(4)–c |
| | Joanette Strain | 32/33(4) ± cn | $\frac{11(1);\ 20}{31}$ |
| 5 | Victory | 34/34(4) ± cn | 31/31(4)– |
| | White Russian | 37/38(3)–cn | 33/33(3)–cn |
| | Richland | 30/31(2)– | 36/37(2)– |
| | Joanette Strain | 33/34(4) ± c | $\frac{12(1)-2(x)=;\ 17}{31}$ |

## THE UREDINIAL DEVELOPMENT OF FIVE PHYSIOLOGIC FORMS ON HOSTS KEPT PRIOR TO INOCULATION AT A LOW (12°C.) AND ALSO AT A HIGH (28°C.) TEMPERATURE (MADISON)

That the uredinial development of certain physiologic forms is influenced by the temperature at which the hosts are kept after inoculation was demonstrated by the previous experiments. The possibility existed that their uredinial development might also be influenced by the temperature at which

TABLE 8.—THE TYPES OF UREDINIAL INFECTION PRODUCED BY FORMS 1, 2, 3, 4 AND 5 ON SEEDLINGS OF FOUR HOSTS KEPT AT DIFFERENT TEMPERATURES.

| Forms | Hosts | Temperatures | |
|---|---|---|---|
| | | 28°C. before and 12°C. after inoculation | 28°C. before and after inoculation |
| 1 | Victory | 34/34(4)- | 31/31(4)±c |
| | White Russian | 37/37(3)-c | 36/37(3)-c |
| | Richland | 31/31(2)- | 30/30(2)- |
| | Joanette Strain | $\frac{10(1)-;\ 21}{31}$ | 33/34(4)±cn |
| 2 | Victory | 28/28(4)- | 30/30(4)±c |
| | White Russian | 31/32(3)- | 33/34(3)-c |
| | Richland | 30/31(2)- | 32/34(2)- |
| | Joanette Strain | 36/36(4)- | 28/28(4)± |
| 3 | Victory | 29/29(4)- | 31/31(4)±cn |
| | White Russian | 30/30(4)-c | 31/33(4)c |
| | Richland | 27/27(2)- | 34/35(2)- |
| | Joanette Strain | $\frac{7(1)-;\ 31}{38}$ | 32/34(4)±cn |
| 4 | Victory | 30/30(4)- | 32/32(4)±c |
| | White Russian | 34/35(4)- | 27/27(4)cn |
| | Richland | 31/31(4)- | 30/32(4)±c |
| | Joanette Strain | $\frac{8(1)-;\ 25}{33}$ | 34/36(4)±cn |
| 5 | Victory | 28/28(4)- | 34/34(4)±c |
| | White Russian | 30/30(3)-c | 30/31(3)-c |
| | Richland | 33/33(2)- | 28/30(2)- |
| | Joanette Strain | $\frac{20(1)-1(x)=;\ 7}{30}$ | 31/31(4)±cn |

the hosts were grown prior to inoculation. An experiment was undertaken to determine what effect there would be on the uredinial development of forms 1, 2, 3, 4 and 5, on the hosts Victory, White Russian, Richland and Joanette Strain in the seedling stage if these varieties were grown, prior to inoculation, at a low (12°C.) and at a high temperature (28°C.). After the hosts grown at 12°C. were inoculated with the various physiologic forms, half were transferred to a chamber maintained at a temperature of 28°C., and the remainder were retained in the chamber at 12°C.; half of the hosts grown prior to inoculation at 28°C. were transferred after inoculation to a chamber kept at a temperature of 12°C., and the remainder were retained in the chamber at 28°C. The chambers maintained at a temperature of 12°C. and at 28°C., were both kept at a relative atmospheric humidity of 75%.

The results of this experiment which are given in Tables 7 and 8, show that the uredinial development of forms 1, 2, 3, 4 and 5 on Victory, White Russian, Richland and Joanette Strain were not appreciably influenced by the temperature at which the hosts were grown prior to inoculation. There was no significant difference in the uredinial development of the various forms whether the hosts were kept at 12°C. both before and after inoculation, or kept at 28°C. before inoculation, and at a temperature of 12°C. afterward. Similarly, there was no significant difference in their uredinial development whether the hosts were kept at 28°C. both before and after inoculation, or kept at 12°C. before, and at a temperature of 28°C. after they were inoculated.

From the results of this experiment, it appears that the temperature at which hosts in the seedling stage are kept prior to inoculation has no appreciable effect upon the uredinial development of the physiologic forms of *P. graminis avenae.* The type of uredinial infection produced by forms 1, 3, 4 and 5 on Joanette Strain, however, is profoundly influenced by the temperature at which this host is kept after inoculation.

### THE UREDINIAL DEVELOPMENT OF FORMS 1, 3, 4 AND 5 ON THE HOST JOANETTE STRAIN WHEN KEPT FOR DIFFERENT LENGTHS OF TIME AFTER INOCULATION AT A TEMPERATURE OF 12°C. AND AT 28°C. (MADISON)

The object of this experiment was to ascertain the effect on the uredinial development of forms 1, 3, 4 and 5 on Joanette Strain in the seedling stage when kept for different lengths of time after inoculation at 12°C., and then transferred to a temperature of 28°C., and also when kept for different lengths of time at 28°C., and then transferred to a temperature of 12°C.

Forty-four pots of seedlings of Joanette Strain were inoculated with each of the four physiologic forms. After inoculation, they were kept as usual for 48 hours in incubation chambers to allow infection to take place. The temperature within the incubation chambers was maintained at approximately 20°C. On removal from the incubation chambers, 22 pots of seedlings inoculated with each form were placed in the temperature-controlled chamber maintained at 12°C., and 22 in the chamber at 28°C. After one day, and on each succeeding day for ten days, two pots were transferred from the low (12°C.) to the high temperature (28°C.), and two from the high (28°C.) to the low temperature (12°C.). Two pots were kept continuously at each temperature as checks.

The uredinial development of the four physiologic forms, expressed as the types of infection produced by them on Joanette Strain, is shown in Tables 9 and 10. The uredinial development of the four forms on Joanette Strain, when kept from one to six days after inoculation at 12°C. before being transferred to a temperature of 28°C., was essentially the same as that which occurred on this host when kept continuously at 28°C. That is, it attained its maximum development. However, when this host was kept for a longer period than six days at 12°C. before being transferred to a temperature of

TABLE 9.—THE TYPES OF UREDINIAL INFECTION PRODUCED BY FORMS 1, 3, 4 AND 5 ON SEEDLINGS OF JOANETTE STRAIN WHEN KEPT FOR DIFFERENT LENGTHS OF TIME AT 12°C. AND THEN TRANSFERRED TO A TEMPERATURE OF 28°C.

| No. of days at 12°C. | Physiologic forms | | | |
|---|---|---|---|---|
| | 1 | 3 | 4 | 5 |
| 1 | 30/30(4)±c | $31/31(4)\overset{\pm}{c}$ | $33/33(4)\overset{\pm}{c}$ | $31/31(4)\overset{\pm}{c}$ |
| 2 | 36/36(4)±c | $32/33(4)\overset{\pm}{c}$ | $34/34(4)\overset{\pm}{c}$ | $32/32(4)\overset{\pm}{c}$ |
| 3 | 33/33(4)c | $38/38(4)\overset{\pm}{c}$ | 31/31(4)c | 36/36(4) |
| 4 | 30/30(4)c | $33/33(4)\overset{\pm}{c}$ | $39/39(4)\overset{\pm}{c}$ | $37/37(4)\overset{\pm}{c}$ |
| 5 | $31/32(4)\bar{c}$ | $37/38(4)\bar{c}$ | 36/37(4) | $31/32(4)\bar{c}$ |
| 6 | $35/35(4)\bar{c}$ | $33/33(4)\bar{c}$ | $38/39(4)\bar{c}$ | $36/36(4)\bar{c}$ |
| 7 | $\frac{14(4)-20(x)+}{34}$ | $\frac{11(x)20(4)}{31}$ | $\frac{21(x)\ 14\ (4)-}{35}$ | $\frac{24(x)\ 11\ (4)-}{35}$ |
| 8 | 31/31(x)± | 38/38(x)± | 34/35(x) | 38/38(x)- |
| 9 | $\frac{5(1)\ 2\ (x)\ ;\ 30}{37}$ | $\frac{3(1)\ 2\ (x)-;\ 30}{35}$ | $\frac{8(1)\ 4\ (x)-;\ 22}{34}$ | $\frac{2(1)\ 6\ (x)\ ;\ 24}{32}$ |
| 10 | $\frac{4(1)\ ;\ 31}{35}$ | $\frac{3(1)\ ;\ 30}{33}$ | $\frac{2(1)\ ;\ 32}{34}$ | $\frac{6(1)\ 1\ (x)=;\ 30}{37}$ |
| Kept continuously at 28°C. | 34/35(4)±cn | 34(4)±cn | 30/30(4)±c | 33/33(4)±c |

TABLE 10.—THE TYPES OF UREDINIAL INFECTION PRODUCED BY FORMS 1, 3, 4 AND 5 ON SEEDLINGS OF JOANETTE STRAIN WHEN KEPT FOR DIFFERENT LENGTHS OF TIME AT 28°C. AND THEN TRANSFERRED TO A TEMPERATURE OF 12°C.

| No. of days at 28°C. | Physiologic forms | | | |
|---|---|---|---|---|
| | 1 | 3 | 4 | 5 |
| 1 | $\frac{4(1)\ ;\ 30}{34}$ | $\frac{3(1)\ ;\ 29}{32}$ | $\frac{2(1)\ ;\ 31}{33}$ | $\frac{7(1)\pm;\ 23}{31}$ |
| 2 | $\frac{10(1)\pm15(x)=;6}{31}$ | $\frac{20(1)\pm1(x)=;10}{35}$ | $\frac{4(1)\pm28(x)=;3}{35}$ | $\frac{2(1)\ 29\ (x)=}{31}$ |
| 3 | 37/37(x)- | $\frac{2(1)\pm31(x)-}{33}$ | 36/36(x)- | 39/39(x)- |
| 4 | $\frac{36(x)+2(4)}{38}$ | $\frac{31(x)c\ 3(4)}{34}$ | $\frac{34(x)+2(4)}{36}$ | $\frac{33(x)c5(4)}{38}$ |
| 5 | $\frac{31(4)c5(x)}{36}$ | $\frac{6(x)31(4)}{37}$ | $\frac{2(x)31(4)c}{34}$ | $\frac{1(x)37(4)c}{38}$ |
| 6 | 31/31(4)c | 33/35(4)c | 36/37(4)c | 35/35(4)c |
| 7 | 32/32(4)c | 36/36(4)c | 37/37(4)c | 31/31(4)c |
| 8 | 38/38(4)c | 39/39(4)c | 37/37(4)c | 38/39(4)c |
| 9 | 37/37(4) | 38/38(4)±c | $38/38(4)\overset{\pm}{c}$ | $32/33(4)\overset{\pm}{c}$ |
| 10 | $39/39(4)\overset{\pm}{c}$ | $33/34(4)\overset{+}{c}$ | $39/39(4)\overset{+}{c}$ | 36/36(4)c |
| Kept continuously at 12°C. | $\frac{5(1)\ ;\ 29}{34}$ | $\frac{3(1)\ ;\ 32}{35}$ | $\frac{4(1)\ ;\ 32}{36}$ | $\frac{7(1)\pm\ ;\ 26}{35}$ |

28°C. the uredinial development was greatly reduced. When retained for ten days at 12°C. before being transferred to a temperature of 28°C., the development of the different forms was in no way different from that which occurred on this host when kept continuously at 12°C.

When this host, after inoculation, was kept first for a number of days at 28°C. before being transferred to a temperature of 12°C., the uredinial development of the four forms was as follows: Kept for one day at 28°C., the uredinial development of the different forms was the same as that at 12°C. for the whole period; kept for a longer time than five days at 28°C., it was the same as that at a temperature of 28°C. for the whole period; kept from two to five days at 28°C., it was intermediate between that produced at a continuous temperature of 12°C. and that at a continuous temperature of 28°C.

### THE UREDINIAL DEVELOPMENT OF FORMS 1, 2, 3, 4 and 5 ON JOANETTE STRAIN IN THE SEEDLING AND MATURE STAGES WHEN KEPT DURING THE DAY AT A HIGH (28°C.) AND AT NIGHT AT A LOW (12°C.) TEMPERATURE (MADISON)

In previous experiments, the uredinial development of forms 1, 3, 4 and 5 on Joanette Strain in the seedling stage has been shown to vary widely, depending on the temperature at which this host was kept after inoculation. When kept at a low temperature (12°C.), the uredinial development of these forms was restricted to the production of flecks and a few small pustules but, at a high temperature (28°C.), numerous large pustules were produced. The object of the present experiment was to ascertain the uredinial development of forms 1, 3, 4 and 5 on Joanette Strain in both the seedling and mature stages when kept during the day at a high temperature (28°C.) and during the night at a low temperature (12°C.). This variation in temperature approximates roughly that occurring in the open during the summer and autumn when the temperature during the day is much higher than it is at night.

Although the uredinial development of form 2 has not been shown to vary appreciably due to temperature, it was included in this experiment for comparison with the other physiologic forms.

The procedure followed was to inoculate nine pots of Joanette Strain in the seedling stage and six pots of this host in the mature stage with each of the five forms mentioned. After inoculation, two pots of seedlings and one pot containing mature plants inoculated with each of these physiologic forms were placed as checks in each of two chambers maintained at a low (12°C.) and at a high temperature (28°C.). The check plants were kept continuously at the two respective temperatures. The remaining five pots of seedlings and four of mature plants were kept during the day in the chamber maintained at a temperature of 28°C. and, at night, in the one at 12°C., thus giving them approximately ten hours each day at the high temperature and 14 hours at the low temperature.

In Tables 11 and 12 is shown the uredinial development of the five forms occurring on Joanette Strain kept at the different temperatures. There was no essential difference between the development of each form on the seedlings and mature plants kept at the same temperatures. The uredinial development of forms 1, 3, 4 and 5, when kept during the day at 28°C. and during the night at a temperature of 12°C., was somewhat greater than their uredinial development when kept continuously at a temperature of 12°C., but much

TABLE 11.—THE TYPES OF UREDINIAL INFECTION PRODUCED BY FORMS 1, 2, 3, 4 AND 5 ON JOANETTE STRAIN IN THE SEEDLING STAGE WHEN KEPT AT DIFFERENT TEMPERATURES

| Forms | Temperatures | | |
|---|---|---|---|
| | Continuously at 12°C. | 28°C. during the day; 12°C. at night | Continuously at 28°C. |
| 1 | $\frac{6(1)\,;\,20}{26}$ | $\frac{26(1) \pm 16(x) -\,;\,17}{59}$ | 26/27(4) ± c |
| 2 | 24/24(4) − | 62/62(4) ± c | 27/27(4) ± c |
| 3 | $\frac{2(1)\,;\,25}{27}$ | $\frac{10(1) \pm 21(x) -\,;\,29}{60}$ | 25/25(4) ± c |
| 4 | $\frac{3(1)\,;\,20}{23}$ | $\frac{27(1) \pm 21(x) -\,;\,14}{62}$ | 23/23(4) ± c |
| 5 | $\frac{4(1)\ 1\,(x) =\,;\,20}{27}$ | $\frac{24(1) \pm 34(x) -\,;\,3}{61}$ | 25/25(4) ± c |

TABLE 12.—THE TYPES OF UREDINIAL INFECTION PRODUCED BY FORMS 1, 2, 3, 4 AND 5 ON JOANETTE STRAIN IN THE MATURE STAGE WHEN KEPT AT DIFFERENT TEMPERATURES.

| Forms | Temperatures | | |
|---|---|---|---|
| | Continuously at 12°C. | 28°C. during the day; 12°C. at night | Continuously at 28°C. |
| 1 | $\frac{3(1) \pm\,;\,2}{5}$ | $\frac{7(1) + 9(x) -\,;\,4}{20}$ | 5/5(4) ± c |
| 2 | 5/5(4) − c | 20/20(4) ± c | 5/5(4) ± c |
| 3 | $\frac{4(1) \pm\,;\,1}{5}$ | $\frac{10(1) + 6(x)\,;\,4}{20}$ | 5/5(4) ± c |
| 4 | $\frac{3(1)\quad;\,2}{5}$ | $\frac{6(1) \pm 9(x) -\,;\,6}{21}$ | 5/5(4) ± c |
| 5 | $\frac{3(1)\ 1\,(x) =\,;\,1}{5}$ | $\frac{1(1) +\,;\,19(x) -}{20}$ | 6/6(4) ± c |

less than that when kept continuously at 28°C. Form 2 attained a similar uredinial development at all temperatures.

### THE UREDINIAL DEVELOPMENT OF NINE PHYSIOLOGIC FORMS ON JOANETTE STRAIN IN THE MATURE STAGE AT FOUR TEMPERATURES (MADISON)

The uredinial development of the nine physiologic forms on Joanette Strain in the seedling stage was investigated at four different temperatures in a previous experiment. Four physiologic forms were found to vary in their uredinial development at these temperatures, while that of the remaining five physiologic forms was essentially the same. The object of this experiment was to ascertain whether the uredinial development of any of the nine forms would vary when Joanette Strain was inoculated in the mature stage and kept at temperatures of 12°, 16°, 24° and 28°C.

The procedure followed during each of three similar trials was to inoculate a number of pots of this host at heading time with urediniospores of each of

TABLE 13.—THE TYPES OF UREDINIAL INFECTION PRODUCED BY NINE PHYSIOLOGIC FORMS ON JOANETTE STRAIN IN THE MATURE STAGE WHEN KEPT AT FOUR DIFFERENT TEMPERATURES.

| Forms | Trial No. | Temperatures | | | |
|---|---|---|---|---|---|
| | | 12°C. | 16°C. | 24°C. | 28°C. |
| 1 | 1 | $\frac{7(1)\pm3(x)=}{10}$ | $\frac{7(1)\pm3(x)=}{10}$ | $\frac{8(x)\overset{+}{c}2(4)c}{10}$ | 8/10(4)–cn |
| | 2 | 5/5(1)±; | 5/5(x)=; | 5/5(4)c | 5/5(4)±cn |
| | 3 | 5/5(1)±; | $\frac{3(1)\pm2(x)=}{5}$ | 5/5(4)c | 5/5(4)±cn |
| 2 | 1 | 9/10(4)±c | 10/10(4)±c | 10/10(4)±c | 9/10(4)±cn |
| | 2 | 5/5(4) | 6/6(4) | $5/5(4)\overset{\pm}{c}$ | 5/5(4)+cn |
| | 3 | 5/5(4)– | 6/6(4) | $5/5(4)\overset{\pm}{c}$ | 5/5(4)–cn |
| 3 | 1 | 0/9 ; 7 | $\frac{1(1)+8(x)=}{10}$ | $\frac{6(x)\overset{+}{c}3(4)c}{10}$ | 10/10(4)–cn |
| | 2 | $\frac{3(1)\pm;2}{6}$ | $\frac{4(1)\pm1(x)=}{5}$ | 6/6(4)±c | 5/5(4)±cn |
| | 3 | $\frac{3(1)\ ;2}{5}$ | 5/5(1)± | 5/5(4)±c | 5/5(4)±cn |
| 4 | 1 | $\frac{2(1)-;7}{10}$ | $\frac{8(1)+2(x)=}{10}$ | $\frac{4(x)\overset{+}{c}\ 6(4)c}{10}$ | 9/10(4)±cn |
| | 2 | $\frac{2(1)-;3}{5}$ | $\frac{3(1)\pm2(x)=}{5}$ | 5/5(4)±c | 5/5(4)±c |
| | 3 | $\frac{3(1)-;2}{5}$ | $\frac{2(1)\pm3(x)=}{5}$ | 5/5(4)c | 5/5(4)±cn |
| 5 | 1 | $\frac{3(1)\pm6(x)-}{9}$ | $\frac{1(1)\pm9(x)-}{10}$ | $\frac{4(x)\overset{+}{c}6(4)c}{10}$ | 9/10(4)cn |
| | 2 | $\frac{2(1)-3(x)=}{5}$ | $\frac{1(1)+4(x)=}{5}$ | 5/5(4)±c | 5/5(4)±cn |
| | 3 | $\frac{3(1)-2(x)=}{5}$ | $\frac{1(1)\pm4(x)=}{5}$ | 5/5(4)±c | 5/5(4)±cn |
| 6 | 1 | 10/10(4)–c | 10/10(4) | 9/9(4)c | 9/9(4)–cn |
| | 2 | 6/6(4)– | 5/5(4)– | 5/5(4)±c | 5/5(4)±cn |
| 7 | 1 | 10/10(4) | 9/9(4) | 9/9(4)c | 9/10(4)±cn |
| | 2 | 5/5(4)– | 5/5(4) | 6/6(4)c | $5/6(4)\overset{\pm}{c}n$ |
| 8 | 1 | 9/9(4)– | 10/10(4) | 10/10(4)c | 10/10(4)–cn |
| | 2 | 5/5(4) - | 5/5(4) | $5/5(4)\overset{+}{c}$ | 5/5(4)±cn |
| 9 | 1 | 10/10(4)– | 10/10(4) | 10/10(4)c | 9/10(4)±cn |
| | 2 | 5/5(4)– | 5/5(4)– | $5/5(4)\overset{+}{c}$ | 5/5(4)±cn |
| 6Y | 1 | 9/9(4)– | 10/10(4) | 10/10(4)c | 9/10(4)±cn |
| | 2 | 5/5(4)– | 5/5(4) | 5/5(4)c | 6/6(4)±cn |
| 7Y | 1 | 10/10(4)– | 10/10(4) | $10/10(4)\overset{+}{c}$ | $10/10(4)\overset{\pm}{c}n$ |
| | 2 | 5/5(4) | 5/5(4) | 5/5(4)c | $5/5(4)\overset{\pm}{c}n$ |

the nine physiologic forms. After the various pots of plants had been kept for the usual length of time in the incubation chambers, one pot of plants inoculated with each physiologic form was placed in each of the four temperature-controlled chambers in the greenhouse maintained at the temperatures just stated.

The uredinial development of the various forms which occurred at the four temperatures is shown in Table 13, and that of forms 1, 2, 3, 4 and 5 is also illustrated in Plates IV and V. Essentially the same results were obtained as when seedlings of Joanette Strain were inoculated. The uredinial development of forms 1, 3, 4 and 5 again varied at the different temperatures, but there was no appreciable difference in that of forms 2, 6, 7, 8 and 9. Temperature, therefore, can be considered to be an important factor in the uredinial development of forms 1, 3, 4 and 5 on Joanette Strain both in the seedling and mature stages. Its influence, however, on the uredinial development of forms 2, 6, 7, 8 and 9 appears to be negligible.

## DISCUSSION AND RESULTS

The results of the experiments on the effect of temperature on the uredinial development of the physiologic forms of *P. graminis avenae* substantiate the findings of Waterhouse (*54*) and those obtained by the writer (*15*) in a preliminary study. They are also in agreement generally with those obtained by a number of other workers (*13*, *19*, *24*, *36*) from studies of the effect of temperature on the uredinial development of physiologic forms of other cereal rusts.

Temperature, within the limits employed (12° to 28°C.), does not appear to induce any significant changes in the types of uredinial infection produced by forms 2, 6, 7, 8 and 9 on the hosts Victory, White Russian, Richland and Joanette Strain. In other words, the reactions of these hosts to the physiologic forms mentioned are only subject to minor fluctuations due to variations in temperature. The fluctuations observed in the reactions of White Russian, Richland and Joanette Strain to forms 2, 6, 7, 8 and 9 are not sufficiently great to complicate the correct identification of these forms.

The types of uredinial infection produced also by forms 1, 3, 4 and 5 on the hosts Victory, White Russian and Richland are not significantly different at any of the temperatures employed. That is, the reactions of these hosts to these four physiologic forms are essentially the same at different temperatures. However, the types of uredinial infection produced on the differential host, Joanette Strain, by forms 1, 3, 4 and 5 at relatively low and high temperatures are profoundly different. This host is quite resistant to these four physiologic forms at low temperatures but is completely susceptible at high tempreatures. At high temperatures, it is no longer differential in its reaction to the nine physiologic forms, as it is completely susceptible to all. Only at low temperatures do the forms 1, 3, 4 and 5 produce on Joanette Strain the characteristic types of infection which have hitherto served for their identification on this host. At a relatively high temperature, or when the temperature fluctuates, these physiologic forms do not produce on this host the types of infections which in the past were accepted as characterizing them.

The results of this study are of importance owing to the bearing which they have on the identification of the physiologic forms of *P. graminis avenae.*

It will be apparent that the work dealing with their identification must be carried on in future at relatively low temperatures, if the various forms are to be classified correctly according to the formerly accepted host reactions. This does not appear to be practicable if the physiologic forms present in a large number of oat stem rust collections are to be identified each year. While the temperature in the greenhouse can be controlled fairly accurately during the winter months, it is almost impossible to obtain accurate control during the whole year. Instead of attempting to identify the physiologic forms present in a large number of oat stem rust collections at accurately controlled temperatures, it appears to be more feasible to group the physiologic forms together which only differ from each other in the types of uredinial infection which they produce on Joanette Strain at a relatively low temperature. The following grouping of certain physiologic forms is suggested for the reasons given.

| | |
|---|---|
| Group I. | Forms 1, 2 and 5. These three physiologic forms only differ in the types of infection which they produce on Joanette Strain. When this host is kept at a relatively high temperature, they are indistinguishable. There is extremely little difference between forms 1 and 5 at all temperatures. |
| Group II. | Forms 3 and 7. These two forms also differ only in the types of uredinial infection which they produce on Joanette Strain. At relatively high temperatures they are indistinguishable. |
| Group III. | Forms 4 and 6. For the same reasons as given for grouping forms 3 and 7. Forms 8 and 9 can be identified, as such, under ordinary environmental conditions occurring in the greenhouses. |

How temperature brings about the changes in the uredinial development of forms 1, 3, 4 and 5 on the host Joanette Strain is obscure. If the effect of temperature is exerted directly on these physiologic forms, it might be supposed that their uredinial development on the other hosts would also be affected. This is not the case. If the effect of the temperature is exerted directly upon the host, Joanette Strain, this effect only occurs when this host is infected by forms 1, 3, 4 and 5. Only one effect of temperature was observed to be exerted equally on all physiologic forms growing on the four hosts, namely, that the incubation period of all forms was greatly extended at relatively low temperatures.

Johnson (*24*) concluded from the results of a study of the effect of temperature on the uredinial development of certain physiologic forms of *P. graminis tritici* that "the effect of temperature is registered on the host-parasite complex." Until more is known about the whole problem of rust resistance, this appears more likely to be the case than that the effect is directly on the host, or parasite. Harrington (*16*) suggests a "curtailment of action of the susceptibility factors", as a genetic hypothesis to explain the action of temperature in inducing rust resistance at a low temperature. This hypothesis is based on the assumption that the effect of temperature is on the host only.

## EFFECT OF TEMPERATURE ON TELIAL DEVELOPMENT

### REVIEW OF LITERATURE ON TELIOSPORE FORMATION

The formation of teliospores by the rust fungi has engaged the attention of numerous investigators for many years. Three different factors have been considered by them to be responsible for telial development. These are:

(1) Condition, or stage of development, of the host; (2) Constitution, or age, of the rust mycelium; (3) Environmental conditions.

One of the earliest theories to account for teliospore formation in the rusts in general was advanced by Magnus (*28*) in 1891. He considered that the production of teliospores was dependent on the condition of the host plant, particularly those parts bearing the parasite. Exhaustion, or previous drying of the host, was regarded as favouring, or even inducing, teliospore formation on the infected plants. Morgenthaler (*31*), working with *Uromyces Veratri* (D.C.) Wint., also considered that the condition of the host was the most important factor in inducing the formation of teliospores, but that the environment was a modifying agent. Klebahn (*25*) was of the opinion that the varying condition of the leaves plays a role in teliospore development. From a study of a number of cereal rusts, Gassner (*11*) concluded that the stage of development of the host governs the formation of teliospores and that climatic conditions, by their effect on the development of the host, can only indirectly, be a factor. The fact that *Puccinia coronata* Corda. developed teliospores on seedling leaves of some varieties of oats was regarded by Parker (*33*) as indicating resistance. Eremeyeva and Karakulin (*4*), from observations on sunflower rust, concluded that the formation of teliospores depended on the physiological condition of the host and not on its age.

In 1910, Jaczewski (*23*) suggested that the formation of teliospores in *Puccinia graminis* Pers. was probably dependent on the age of the mycelium, since climatic conditions apparently played no role. Raines (*38*), in 1922, expressed the opinion that teliospore formation in *Puccinia coronifera* Kleb. indicated the protoplasmic constitution of the fungus mycelium as a possible factor. This view has received support from investigations made more recently. Bailey (*1*), in 1925, found that forms 3 and 4 of *P. graminis avenae* formed teliospores much more rapidly than forms 1, 2 and 5. As forms 3 and 4 are much more virulent than the latter, a correlation between rapidity of teliospore formation and virulence was suggested. Parson (*34*), working with *P. coronata avenae*, and Hey (*19*), with *Puccinia simplex* Erikss. and Henn., observed striking differences also in the rapidity of telial development by various physiologic forms.

A number of investigators have regarded environmental factors as being of importance in the formation of teliospores by various rust fungi. Hennings (*18*), in 1901, was of the opinion that climatic conditions as well as the physical condition of the host might be the cause of teliospore formation. A few years later, Smith (*41*) observed that teliospore formation in *Puccinia asparagi* D.C. was rapidly brought about by high soil moistures, and appeared to be also favoured by dry winds and cool nights. In 1907, Ivanoff (*22*) determined by experiments that low temperatures were more favourable for the telial development of *Puccinia pimpinellae* (Strs.) Link., *Puccinia Galii* Schw., *Puccinia violae* (Schum.) D.C., and *Puccinia Celakowskyana* Bub. From a study of the telial development of several rust fungi, Waters (*55*) concluded that such factors as light, temperature and moisture may so influence the metabolism of the host that the fungus reacts by changing from the uredinial to the telial stage. That is, environmental factors are of importance, but are indirect in their action. Johnson (*24*), working with physiologic forms of *P. graminis tritici*, found that relatively high temperatures favoured rapid teliospore formation, but that there were inherent differences also between forms in respect to their telial development. He observed also that most rapid telial development occurred at the nodes of the plants. In other words, environmental factors, constitution of the fungus mycelium and specific host tissues had some effect on teliospore formation. Melander (*30*) noted that the production of telia by *P. graminis* on wheat, oats and rye was stimulated at a low temperature (0 to 1°C.).

### SCOPE OF STUDIES ON THE EFFECT OF TEMPERATURE ON TELIAL DEVELOPMENT

The effect of temperature on the telial development of the physiologic forms of *P. graminis avenae* was determined by inoculating certain hosts in the seedling and mature stages and then keeping them at different temperatures until the formation of teliospores was completed. With few exceptions, the various experiments were carried on at constant temperatures. As the variety Victory is susceptible to all the forms, it was employed most frequently in this part of the investigation, although in certain experiments, White Russian was also used.

In the experiments in which seedlings were inoculated, the number of seedlings bearing teliospores was recorded each day, from the end of the incubation period of the uredinia until telia were present on all the infected plants, or until further telial development was prevented by the death of the plants. From the data obtained, both the rate and extent of telial development of the various forms at the same, or different, temperatures could be compared. The rate was determined by calculating the mean of the number of days required for a physiologic form to attain complete telial development after the end of the incubation period, that is, after the first appearance of uredinia. Complete telial development of a form was considered to have been reached when telia were formed on all infected seedlings, or when further formation of teliospores was prevented by the death of the seedlings. The extent of telial development of the various physiologic forms at the same, or different, temperatures could be determined by calculating the percentage of infected seedlings on which telia were formed. A statistical analysis of the data obtained was carried out to determine the significance of the differences observed in both the rate and extent of telial development in the various physiologic forms kept at different temperatures.

When the hosts were inoculated in the mature stage, observations on teliospore formation were made each day from the end of the incubation period until teliospores were present in all uredinial pustules. The observations recorded on the rate of formation of teliospores in the various forms at different temperatures included the following data:

1. The number of days from inoculation to the formation of the first teliospores.
2. The number of days from inoculation until complete telial development had taken place.
3. The number of days from the formation of the first teliospores until until complete telial development took place.
4. The number of days from the end of the incubation period until the first teliospores were formed.
5. The number of days from the end of the incubation period until the formation of teliospores was completed.

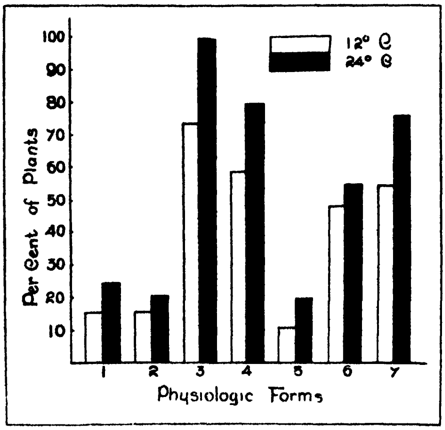
### THE FORMATION OF TELIOSPORES ON VICTORY IN THE SEEDLING STAGE BY SEVEN PHYSIOLOGIC FORMS AT LOW AND HIGH TEMPERATURES (WINNIPEG)

In this experiment observations were made on the formation of teliospores in forms 1, 2, 3, 4, 5, 6 and 7 on Victory in the seedling stage at a low (12°C.) and a high temperature (24°C.). The procedure followed during each of three similar trials was to inoculate seven sets of approximately 100 seedlings of Victory with urediniospores, a different form being used for each set. Half of the seedlings of each set were later placed in a greenhouse section maintained at the low temperature and the other half of each set in a section held at the high temperature, until the formation of teliospores was completed.

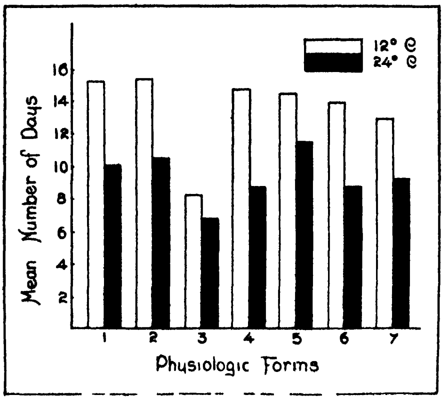
In making the statistical analysis of the results obtained at the two temperatures, the total number of seedlings under observation during the three trials were employed. The significance of the difference between the telial development of each physiologic form at the two temperatures was determined by calculating the value of $\chi^2$, according to the method of Fisher (7). The values of the 5% point were also obtained by referring to the Tables of Fisher (7).

The method of analyzing the data concerning the telial development of each physiologic form on seedlings kept at the low and high temperatures is shown in Tables 15 and 16. The significance of the difference between the extent of the telial development in form 4 at temperatures of 12° and 24°C. was determined as shown in Table 15. In Table 16 is shown the analysis of the data concerning the rate of telial development in form 4 at the two temperatures. Data concerning the extent and rate of telial development of the other physiologic forms at the low and high temperatures were analyzed in the same manner.

The results of this experiment are presented in Table 14, and are illustrated graphically in Text Figures 5 and 6. The extent of the telial development of all physiologic forms was greater at the high (24°C.) than at the low temperature (12°C.) (Text Figure 5). With certain physiologic forms, however, the



Text Figure 5. The percentage of Victory seedlings bearing telia when infected by seven physiologic forms and kept at low and high temperatures.



Text Figure 6. The mean number of days taken by seven physiologic forms to attain complete telial development on seedlings of Victory kept at low and high temperatures.

differences in the extent of their telial development at the two temperatures were not significant, as indicated by the value of $\chi^2$ (Table 14). Differences are considered significant when the value of $\chi^2$ is equal to, or greater than, the 5% point.

The rate of telial development of all forms was faster at the high than at the low temperature. In all cases the differences may be considered significant (Table 14). The differences in the rate of telial development of all forms at the two temperatures are shown by means of a graph in Text Figure 6.

TABLE 14.—A STATISTICAL ANALYSIS OF THE EXTENT AND RATE OF TELIOSPORE FORMATION IN SEVEN PHYSIOLOGIC FORMS ON VICTORY IN THE SEEDLING STAGE WHEN KEPT AT LOW AND HIGH TEMPERATURES.

| Forms | Temperatures | Percentage of infected seedlings bearing telia | $\chi^2$ | 5 per cent point | Mean No. of days taken to form telia | $\chi^2$ | 5 per cent point |
|---|---|---|---|---|---|---|---|
| 1 | 12°C. | 15.8 | 2.9 | 3.8 | 15.4 | 22.2 | 7.8 |
| | 24°C. | 23.9 | | | 10.1 | | |
| 2 | 12°C. | 16.3 | .7 | 3 8 | 15.5 | 15.4 | 7.8 |
| | 24°C. | 20.1 | | | 10.5 | | |
| 3 | 12°C. | 72.8 | 43.9 | 3.8 | 8.3 | 26.3 | 9.5 |
| | 24°C. | 98.7 | | | 6.8 | | |
| 4 | 12°C. | 57.6 | 17.4 | 3.8 | 14.8 | 51.2 | 7.8 |
| | 24°C. | 79.0 | | | 8.7 | | |
| 5 | 12°C. | 11.2 | 4.0 | 3.8 | 14.5 | 8.9 | 6.0 |
| | 24°C. | 19.6 | | | 11.5 | | |
| 6 | 12°C. | 47.0 | 4.7 | 3.8 | 14.0 | 63.4 | 7.8 |
| | 24°C. | 54.3 | | | 8.7 | | |
| 7 | 12°C. | 53.9 | 14.9 | 3.8 | 13.0 | 68.8 | 9.5 |
| | 24°C. | 75.2 | | | 9.3 | | |

The influence of temperature on the formation of teliospores by the various physiologic forms appeared to be as follows. A high temperature was conducive to a rapid development of teliospores, while a low temperature retarded their formation. Teliospores were formed also on a larger percentage of infected seedlings at the high (24°C.) than at the low temperature (12°C.).

Differences in the telial development of the various forms were evident. Forms 1, 2 and 5 formed telia on a smaller percentage of the infected seedlings, and did so more slowly, than forms 3, 4, 6 and 7. Form 3 developed telia on a greater percentage of infected plants, and formed them more rapidly at both temperatures, than any of the other physiologic forms.

TABLE 15.—DISTRIBUTION OF VICTORY SEEDLINGS ON WHICH TELIOSPORES FORMED, OR FAILED TO FORM, AT TWO TEMPERATURES WHEN INFECTED BY FORM 4.

| | Number of seedlings | | |
|---|---|---|---|
| | Formed | Failed | Totals |
| 12°C. | 87 | 64 | 151 |
| 24°C. | 139 | 37 | 176 |
| Totals | 226 | 101 | 327 |

$\chi^2 = 17.4$ 5 per cent point = 3.8

TABLE 16.—DISTRIBUTION OF VICTORY SEEDLINGS AT TWO TEMPERATURES, ON WHICH TELIOSPORES WERE FORMED BY FORM 4 DURING FOUR CONSECUTIVE FIVE-DAY PERIODS FROM THE END OF THE INCUBATION PERIOD.

| | Number of seedlings bearing telia during each five-day period | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | Totals |
| 12°C. | 1 | 27 | 38 | 21 | 87 |
| 24°C. | 69 | 36 | 32 | 2 | 139 |
| Totals | 70 | 63 | 70 | 23 | 226 |

$\chi^2 = 51.2$ 5 per cent point = 7.8

## THE FORMATION OF TELIOSPORES ON WHITE RUSSIAN IN THE SEEDLING STAGE BY EIGHT PHYSIOLOGIC FORMS AT LOW AND HIGH TEMPERATURES

(WINNIPEG)

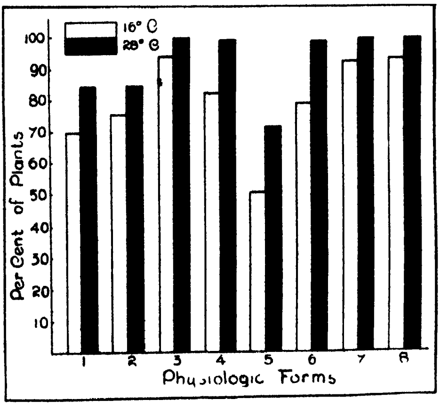
The effect of temperature on the formation of teliospores of eight physiologic forms on White Russian in the seedling stage was determined in the following experiment. In each of three trials approximately 800 seedlings of this host were inoculated with urediniospores, a different physiologic form being used to inoculate each 100 seedlings.

After inoculation, one-half the number of the seedlings inoculated with each form was kept in a section of a greenhouse maintained at 16°C., and the other half was placed in a section kept at 28°C. Observations on telial development were recorded in the usual manner. The object of this experiment was to determine whether the telial development of the various forms on this host would be more extensive and more rapidly initiated at the high temperature than at the low, as was the case when Victory was used as the host.

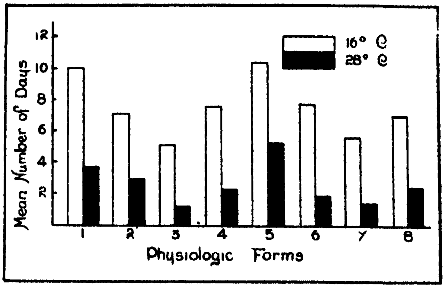
The results of this experiment, analyzed statistically, are presented in Table 17. Again, teliospore formation by all forms was more extensive at the high (28°C.) than at the low temperature (16°C.). Teliospores were formed on a greater percentage of the seedlings infected by all forms at the high temperature, as is shown graphically in Text Figure 7. There was also a shorter period of time taken for the formation of the teliospores at the high temperature, as shown by means of the graph in Text Figure 8. The statistical analysis of the results obtained at the two temperatures show that the differences between the telial development which occurred at the low (16°C.) and high temperature (28°C.) may be considered significant (Table 17). In all cases the value of $\chi^2$ is greater than that of the 5% point.

TABLE 17.—A STATISTICAL ANALYSIS OF THE EXTENT AND RATE OF TELIOSPORE FORMATION IN EIGHT PHYSIOLOGIC FORMS IN WHITE RUSSIAN IN THE SEEDLING STAGE WHEN KEPT AT LOW AND HIGH TEMPERATURES.

| Forms | Temperatures | Percentage of infected seedlings bearing telia | $\chi^2$ | 5 per cent point | Mean No. of days taken to form telia | $\chi^2$ | 5 per cent point |
|---|---|---|---|---|---|---|---|
| 1 | 16°C. | 69.7 | 15.2 | 3.8 | 10.0 | 218.0 | 7.8 |
|  | 28°C. | 84.8 |  |  | 3.7 |  |  |
| 2 | 16°C. | 75.8 | 5.2 | 3.8 | 7.0 | 243.9 | 7.8 |
|  | 28°C. | 84.7 |  |  | 2.8 |  |  |
| 3 | 16°C. | 95.0 | 10.9 | 3.8 | 5.1 | 147.5 | 6.0 |
|  | 28°C. | 100.0 |  |  | 1.2 |  |  |
| 4 | 16°C. | 82.5 | 37.9 | 3.8 | 7.6 | 236.3 | 6.0 |
|  | 28°C. | 99.1 |  |  | 2.3 |  |  |
| 5 | 16°C. | 50.3 | 20.7 | 3.8 | 10.5 | 89.1 | 7.8 |
|  | 28°C. | 72.6 |  |  | 5.3 |  |  |
| 6 | 16°C. | 78.4 | 42.4 | 3.8 | 7.8 | 296.9 | 6.0 |
|  | 28°C. | 98.6 |  |  | 1.9 |  |  |
| 7 | 16°C. | 92.3 | 16.8 | 3.8 | 5.6 | 190.9 | 6.0 |
|  | 28°C. | 100.0 |  |  | 1.4 |  |  |
| 8 | 16°C. | 93.6 | 12.4 | 3.8 | 6.9 | 202.8 | 6.0 |
|  | 28°C. | 100.0 |  |  | 2.4 |  |  |



Text Figure 7. The percentage of White Russian seedlings bearing telia when infected by eight physiologic forms and kept at low and high temperatures.



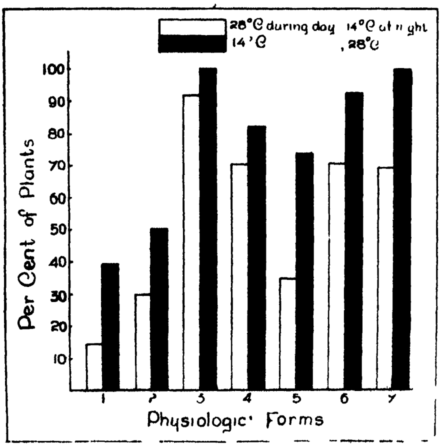
Text Figure 8. The mean number of days taken by eight physiologic forms to attain complete telial development on seedlings of White Russian kept at low and high temperatures.

Although forms 1, 2 and 5 developed teliospores on a greater percentage of the White Russian seedlings than when Victory was employed as a host, they formed teliospores less extensively than the other physiologic forms.

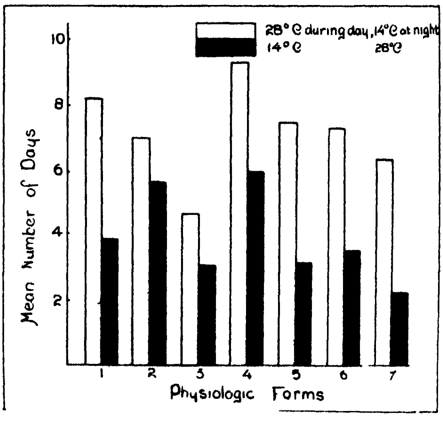
### THE FORMATION OF TELIOSPORES BY SEVEN PHYSIOLOGIC FORMS ON VICTORY IN THE SEEDLING STAGE WHEN KEPT DURING THE DAY AND NIGHT AT DIFFERENT TEMPERATURES (WINNIPEG)

When teliospores are formed during the autumn under natural conditions the temperature is variable. During the day it is usually much higher than at night. In addition to the higher temperature occurring during the day, sunlight is present, while at night there is a combination of low temperature and darkness. In this experiment the teliospore formation of forms 1, 2, 3, 4, 5, 6 and 7, was observed on Victory in the seedling stage under environmental conditions approximating those occurring in nature during the autumn. Two sections of a greenhouse, one maintained at a high (28°C.) and the other at a low temperature (14°C.) were employed. In each of the three similar trials approximately 700 seedlings of Victory were inoculated with urediniospores, a different physiologic form being used to inoculate each 100 seedlings. After inoculation, half of the seedlings inoculated with each physiologic form were kept during the day at 28°C. and during the night at 14°C.; the other half were kept during the day at 14°C. and during the night at 28°C. Observations on the teliospore formation of the various physiologic forms were made in the usual manner. The incubation period was ten days under both sets of environmental conditions.

The results obtained in this experiment, analyzed statistically, are presented in Table 18. All physiologic forms formed teliospores on a greater percentage of infected seedlings when kept during the day at 14°C. and at a temperature of 28°C. at night than when kept during the day at 28°C. and at a temperature of 14°C. at night. This difference between the seven physiologic forms in the extent of their telial development under the different



Text Figure 9. The percentage of Victory seedlings bearing telia when infected by seven physiologic forms and kept under different environmental conditions.



Text Figure 10. The mean number of days taken by seven physiologic forms to attain complete telial development on seedlings of Victory kept under different en- environmental conditions.

environmental conditions is illustrated graphically in Text Figure 9. The different forms also attained complete telial development more rapidly on the seedlings when kept during the day at 14°C. and at a temperature of 28°C. at night, than when kept at 28°C. during the day and at a temperature of 14°C. at night. A comparison of the rate of telial development of the seven physiologic forms is made by means of a graph in Text Figure 10. It would appear from these results that a low temperature combined with light and a high temperature along with darkness are more conducive to telial development of these physiologic forms at least than a high temperature with light and a low temperature with darkness.

TABLE 18.—A STATISTICAL ANALYSIS OF THE EXTENT AND RATE OF TELIOSPORE FORMATION IN SEVEN PHYSIOLOGIC FORMS ON VICTORY IN THE SEEDLING STAGE WHEN KEPT UNDER DIFFERENT ENVIRONMENTAL CONDITIONS.

| Forms | Environmental conditions | Percentage of infected seedlings bearing telia | $\chi^2$ | 5 per cent point | Mean No. of days taken to form telia | $\chi^2$ | 5 per cent point |
|---|---|---|---|---|---|---|---|
| 1 | 28°C. during day; 14°C. at night | 14.0 | 24.6 | 3.8 | 8.2 | 15.8 | 6.0 |
| | 14°C. during day; 28°C. at night | 39.3 | | | 3.8 | | |
| 2 | 28°C. during day; 14°C. at night | 29.6 | 24.3 | 3.8 | 7.0 | 7.0 | 7.8 |
| | 14°C. during day; 28°C. at night | 51.1 | | | 5.6 | | |
| 3 | 28°C. during day; 14°C. at night | 92.8 | 12.1 | 3.8 | 4.6 | 17.4 | 6.0 |
| | 14°C. during day; 28°C. at night | 100.0 | | | 3.1 | | |
| 4 | 28°C. during day; 14°C. at night | 70.5 | 6.6 | 3.8 | 9.3 | 47.4 | 7.8 |
| | 14°C. during day; 28°C. at night | 82.6 | | | 5.9 | | |
| 5 | 28°C. during day; 14°C. at night | 34.2 | 54.8 | 3.8 | 7.4 | 42.5 | 7.8 |
| | 14°C. during day; 28°C. at night | 74.8 | | | 3.2 | | |
| 6 | 28°C. during day; 14°C. at night | 71.8 | 22.7 | 3.8 | 7.3 | 108.5 | 7.8 |
| | 14°C. during day; 28°C. at night | 92.6 | | | 3.5 | | |
| 7 | 28°C. during day 14°C. at night | 69.9 | 60.8 | 3.8 | 6.2 | 86.5 | 7.8 |
| | 14°C. during day; 28°C. at night | 100.0 | | | 2.2 | | |

TABLE 19.—DATA CONCERNING THE EXTENT AND RATE OF TELIAL DEVELOPMENT OF NINE PHYSIOLOGIC FORMS ON SEEDLINGS OF VICTORY KEPT AT FOUR DIFFERENT TEMPERATURES.

| Forms | Temperature °C. | Extent of Telial Development: Percentage of infected seedlings bearing telia | Rate of Telial Development: Mean number of days taken to form telia |
|---|---|---|---|
| 1 | 12° | 30.8 | 12.7 |
| | 16° | 34.4 | 12.3 |
| | 24° | 46.4 | 10.5 |
| | 28° | 52.0 | 8.7 |
| 2 | 12° | 29.1 | 12.3 |
| | 16° | 36.1 | 11.3 |
| | 24° | 43.9 | 10.6 |
| | 28° | 48.7 | 9.3 |
| 3 | 12° | 71.8 | 9.1 |
| | 16° | 79.5 | 8.5 |
| | 24° | 91.3 | 5.9 |
| | 28° | 95.4 | 4.4 |
| 4 | 12° | 56.9 | 10.1 |
| | 16° | 67.6 | 8.8 |
| | 24° | 80.4 | 7.7 |
| | 28° | 82.8 | 5.6 |
| 5 | 12° | 29.0 | 12.8 |
| | 16° | 33.7 | 10.1 |
| | 24° | 41.8 | 9.8 |
| | 28° | 55.6 | 8.8 |
| 6 | 12° | 49.7 | 8.9 |
| | 16° | 62.3 | 7.5 |
| | 24° | 78.0 | 6.1 |
| | 28° | 79.6 | 5.4 |
| 7 | 12° | 60.4 | 9.0 |
| | 16° | 70.5 | 8.4 |
| | 24° | 84.0 | 6.0 |
| | 28° | 91.3 | 4.2 |
| 8 | 12° | 48.3 | 9.0 |
| | 16° | 61.8 | 8.7 |
| | 24° | 75.9 | 7.2 |
| | 28° | 83.6 | 5.6 |
| 9 | 12° | 42.1 | 9.4 |
| | 16° | 53.9 | 8.8 |
| | 24° | 72.6 | 6.5 |
| | 28° | 83.6 | 5.1 |
| 6Y | 12° | 36.0 | 10.1 |
| | 16° | 42.8 | 9.1 |
| | 24° | 53.6 | 7.5 |
| | 28° | 62.4 | 7.2 |
| 7Y | 12° | 40.5 | 9.6 |
| | 16° | 46.5 | 8.7 |
| | 24° | 61.0 | 7.4 |
| | 28° | 71.1 | 6.6 |

### THE FORMATION OF TELIOSPORES BY NINE PHYSIOLOGIC FORMS ON VICTORY IN THE SEEDLING STAGE KEPT AT FOUR DIFFERENT TEMPERATURES (MADISON)

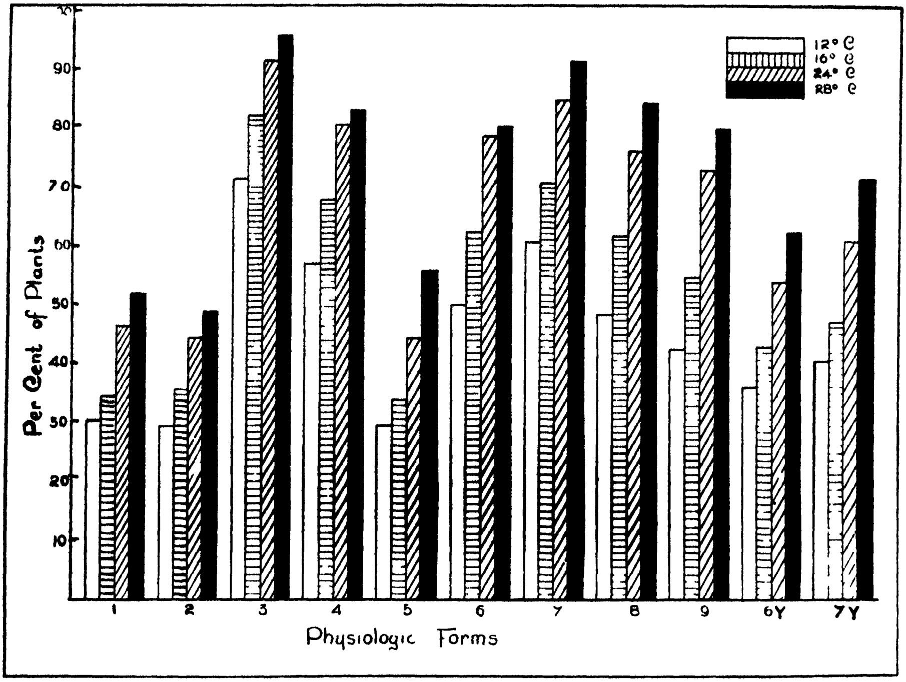
The effect of temperature on the formation of teliospores by the nine physiologic forms of *P. graminis avenae* was determined in this experiment. In addition to the nine normal physiologic forms, forms 6Y and 7Y, yellow in colour, were also available.

During each of two trials approximately 3,300 seedlings of Victory were inoculated with urediniospores, a different physiologic form being used to inoculate each 300 seedlings. Approximately one-quarter of the seedlings inoculated with each physiologic form were later kept in each of four temperature-controlled chambers maintained at temperatures of 12°, 16°, 24° and 28°C. Observations on the telial development of the various physiologic forms kept at the four different temperatures were recorded in the usual manner. The incubation period of all the physiologic forms at the four different temperatures was as follows: 12°C., 16 days; 16°C., 12 days; 24°C., 8 days; 28°C., 9 days.

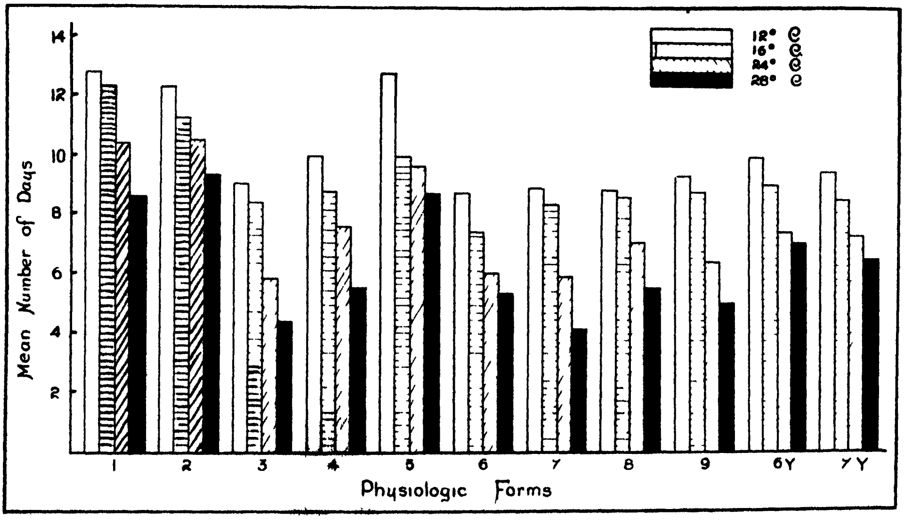
Data concerning the extent and rate of telial development of the various physiologic forms on Victory in the seedling stage when kept at the four temperatures are presented in Table 19. The extent of the telial development in all the physiologic forms varied with the temperature. At the lowest temperature (12°C.), teliospores were formed on the least percentage of the seedlings. At the temperatures higher than 12°C., the percentage of infected seedlings bearing teliospores increased with the temperature. The data are shown graphically in Text Figure 11. Forms 1, 2 and 5 formed teliospores on a smaller percentage of the seedlings than any of the other physiologic forms. Forms 3 and 7 produced the most extensive development of telia.

Teliospores were formed most slowly by all physiologic forms at the lowest temperature (12°C.), while the most rapid telial development occurred at the highest temperature (28°C.). A comparison of the mean number of days taken by each physiologic form to attain complete telial development on seedlings of Victory when kept at the four different temperatures is made graphically in Text Figure 12. It will be evident that forms 1, 2 and 5 attained complete telial development more slowly than any of the other forms.

That temperature has quite a marked effect on teliospore formation will be apparent from Table 20. In this table, the data concerning the extent and rate of telial development of each physiologic form kept at the four different temperatures are grouped in such a way as to bring out the differences in teliospore formation at low and high temperatures. Data relating to telial development which occurred at the two low temperatures (12° and 16°C.) were grouped, as were those at the two high temperatures (24° and 28°C.). The differences shown both between the extent and rate of telial development of each of the various physiologic forms kept at the two low temperatures (12° and 16°C.) and at the two high temperatures (24° and 28°C.) may be considered significant, as indicated by the values of $\chi^2$. The results of the present experiment indicate quite definitely that both the extent and rate of telial development of the different physiologic forms on seedlings of Victory are increased by high temperatures.



Text Figure 11. The percentage of Victory seedlings bearing telia when infected by nine physiologic forms and kept at four different temperatures



Text Figure 12. The mean number of days taken by nine physiologic forms to attain complete telial development on seedlings of Victory at four different temperatures.

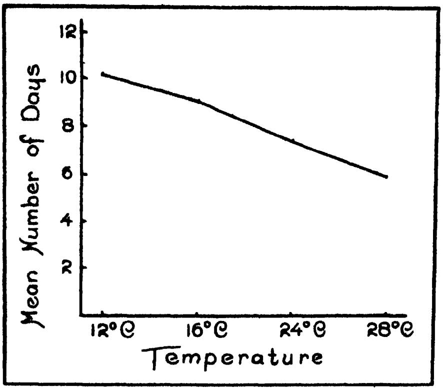
TABLE 20.—DATA CONCERNING THE EXTENT AND RATE OF TELIAL DEVELOPMENT OF NINE PHYSIOLOGIC FORMS WHEN KEPT AT LOW (12° AND 16°C.) AND HIGH TEMPERATURES (24° AND 28°C.).

| Forms | Temperatures °C. | Extent of Telial Development: Percentage of infected seedlings bearing telia | $\chi^2$ | 5 per cent point | Rate of Telial Development: Mean number of days taken to form telia | $\chi^2$ | 5 per cent point |
|---|---|---|---|---|---|---|---|
| 1 | 12°, 16° | 32.7 | 16.8 | 3.8 | 12.4 | 36.7 | 6.0 |
| | 24°, 28° | 49.1 | | | 9.5 | | |
| 2 | 12°, 16° | 32.5 | 16.0 | 3.8 | 11.8 | 16.0 | 6.0 |
| | 24°, 28° | 46.3 | | | 9.9 | | |
| 3 | 12°, 16° | 75.6 | 36.2 | 3.8 | 8.8 | 81.4 | 6.0 |
| | 24°, 28° | 93.4 | | | 5.2 | | |
| 4 | 12°, 16° | 62.3 | 24.7 | 3.8 | 9.4 | 66.1 | 6.0 |
| | 24°, 28° | 81.6 | | | 6.6 | | |
| 5 | 12°, 16° | 31.4 | 18.6 | 3.8 | 11.3 | 27.0 | 6.0 |
| | 24°, 28° | 48.8 | | | 9.3 | | |
| 6 | 12°, 16° | 55.9 | 23.9 | 3.8 | 8.1 | 55.8 | 6.0 |
| | 24°, 28° | 78.8 | | | 5.7 | | |
| 7 | 12°, 16° | 65.4 | 40.9 | 3.8 | 8.7 | 92.7 | 6.0 |
| | 24°, 28° | 87.6 | | | 5.1 | | |
| 8 | 12°, 16° | 55.1 | 41.5 | 3.8 | 8.8 | 61.5 | 6.0 |
| | 24°, 28° | 79.8 | | | 6.3 | | |
| 9 | 12°, 16° | 47.9 | 48.5 | 3.8 | 9.1 | 73.7 | 6.0 |
| | 24°, 28° | 75.9 | | | 5.8 | | |
| 6Y | 12°, 16° | 39.3 | 20.7 | 3.8 | 11.2 | 21.6 | 6.0 |
| | 24°, 28° | 57.9 | | | 6.3 | | |
| 7Y | 12°, 16° | 43.4 | 30.9 | 3.8 | 9.1 | 33.9 | 6.0 |
| | 24°, 28° | 66.0 | | | 7.0 | | |

The relation of temperature to the rate of teliospore formation in stem-rust of oats (*P. graminis avenae*) on seedlings of Victory is shown by means of a graph in Text Figure 13. The rate of formation at each of the four different temperatures is expressed by the mean number of days taken by all the physiologic forms to attain complete telial development. It would appear evident that, within the temperature range of this experiment, the rate of formation of teliospores in this rust is increased by a rise in temperature.

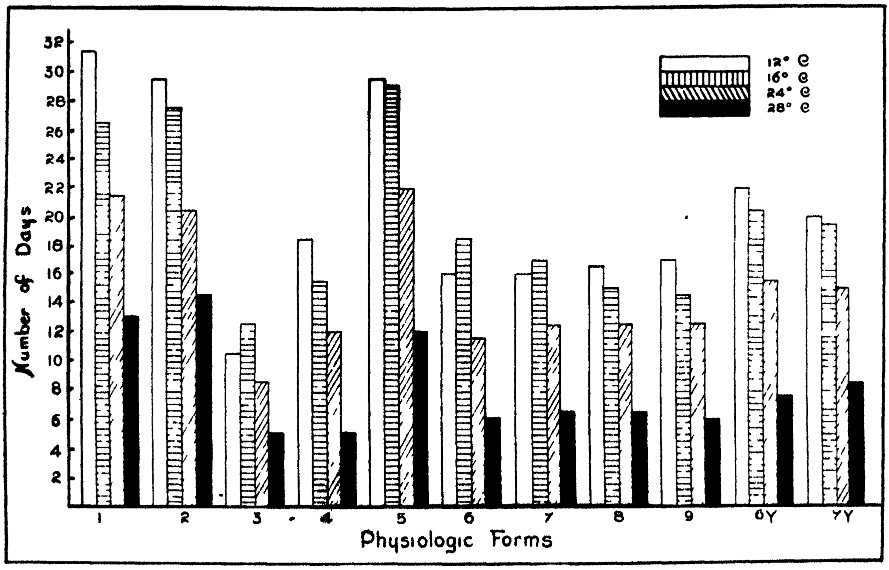
## THE FORMATION OF TELIOSPORES BY NINE PHYSIOLOGIC FORMS ON VICTORY IN THE MATURE STAGE AT FOUR TEMPERATURES (MADISON)

In this experiment, the formation of teliospores in nine physiologic forms of *P. graminis avenae* was investigated on Victory in the mature stage. Forms 6Y and 7Y, yellow in colour, were also included. During each of two similar trials, a set of four pots of Victory in the mature stage was inoculated with form 1, a second set with form 2, and so on for the other forms. Each pot contained five plants. After the pots were removed from the incubation chambers, one pot of each set was placed in each of the four controlled chambers maintained at temperatures of 12°, 16°, 24° and 28°C. Observations were made daily on the telial development of the different physiologic forms. The incubation period of all physiologic forms on the mature plants was the same as that which occurred when seedlings were inoculated.



Text Figure 13. A graph showing the relation of temperature to the rate of telial development by *P. graminis avenae* on seedlings of Victory: the mean number of days taken by the nine physiologic forms to attain complete telial development on seedlings of Victory kept at four different temperatures.

Data concerning the formation of teliospores by the nine physiologic forms on Victory in the mature stage when kept at the four different temperatures are presented in Tables 21 to 24. The number of days taken by the different forms to attain complete telial development from the end of the



Text Figure 14. A comparison of the rate of teliospore formation by nine physiologic forms on Victory in the mature stage kept at four different temperatures.

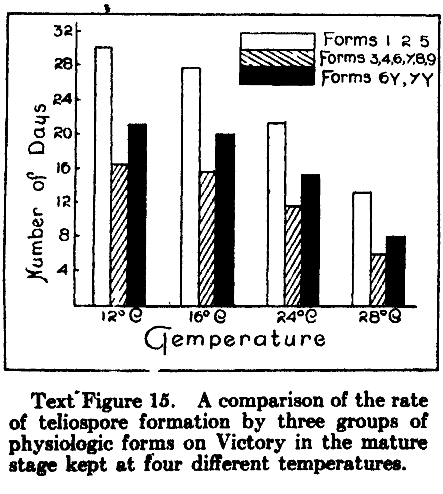
incubation period is employed in Text Figure 14 as the index for the comparison of their rate of telial development at the four different temperatures. It will be evident from Text Figure 14 that all the physiologic forms produced teliospores most rapidly at a temperature of 28°C. At successively lower temperatures their rate of telial development, with few exceptions, was more and more decreased. These results are in close agreement with those obtained when seedlings were inoculated with the same physiologic forms and kept at the same temperatures. It would appear that high temperatures are most favourable for the rapid telial development of all the physiologic forms on both seedlings and mature plants.

Forms 1, 2 and 5 again formed teliospores more slowly at each of the four different temperatures than the other physiologic forms. This was the case when the rate of their telial development was determined on Victory in the seedling stage. Forms 6Y and 7Y formed teliospores more rapidly than forms 1, 2 and 5, but more slowly than forms 3, 4, 6, 7, 8 and 9. Data concerning the rate of telial development of these three groups of physiologic forms at the four temperatures, are presented in Table 25. The mean number of days is stated in each case. A comparison of the rate of formation of teliospores by the three groups of physiologic forms kept at the four different temperatures is made graphically in Text Figure 15. The number of days taken by each group of physiologic forms to attain complete telial development from the end of the incubation period was employed as the index of the rate in each case.

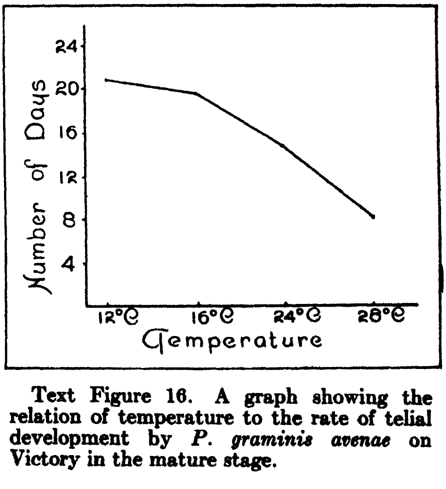
The relation of temperature to the rate of telial development of *P. graminis avenae* on Victory in the mature stage is shown by means of a graph in Text Figure 16. The mean number of days taken by all the physiologic forms to attain complete telial development from the end of the incubation period was employed as the index of the rate of telial development.

## THE FORMATION OF TELIOSPORES BY EIGHT PHYSIOLOGIC FORMS ON VICTORY AND WHITE RUSSIAN IN THE MATURE STAGE KEPT UNDER DIFFERENT ENVIRONMENTAL CONDITIONS (WINNIPEG)

The rate of formation of teliospores by eight physiologic forms on the hosts Victory and White Russian in the mature stage was determined under



Text Figure 15. A comparison of the rate of teliospore formation by three groups of physiologic forms on Victory in the mature stage kept at four different temperatures.



Text Figure 16. A graph showing the relation of temperature to the rate of telial development by *P. graminis avenae* on Victory in the mature stage.

different environmental conditions. In this experiment 48 pots of each host were inoculated with urediniospores, six pots of Victory and six of White Russian being inoculated with form 1, the same number of each host with form 2, and similarly for the other six forms. After inoculation, the various pots of hosts were apportioned as follows. Two out of the six pots of each host inoculated with form 1 were placed in a cold section of the greenhouse and two in a warm section. A similar distribution was made for each of the other forms. Accurate control of the temperature could not be obtained in either of the two sections, as this experiment was carried on during May and June, when the sun's rays were strong. The mean temperatures, however, of the two sections were quite different, being 16°C. in the cold section during this experiment and 26°C. in the warm section. The two remaining pots were placed outside the greenhouse where wide variations occurred in the environment.

TABLE 21.—DATA CONCERNING THE RATE OF TELIAL DEVELOPMENT OF NINE PHYSIOLOGIC FORMS ON VICTORY IN THE MATURE STAGE WHEN KEPT AT A TEMPERATURE OF 12°C.

| Forms | Number of days | | | | |
|---|---|---|---|---|---|
| | From inoculation to first telial development | From inoculation to complete telial development | From first telia to complete telial development | From end of incubation period to first telial development | From end of incubation period to complete telial development |
| 1 | 27 | 47.5 | 20.5 | 11 | 31.5 |
| 2 | 25.5 | 45.5 | 20 | 9.5 | 29.5 |
| 3 | 16.5 | 26.5 | 10 | .5 | 10.5 |
| 4 | 19 | 35 | 16 | 3 | 19 |
| 5 | 26.5 | 45.5 | 19 | 10.5 | 29.5 |
| 6 | 20 | 35.5 | 15.5 | 4 | 16 |
| 7 | 20 | 32 | 12 | 4 | 16 |
| 8 | 20 | 32.5 | 12.5 | 4 | 16.5 |
| 9 | 20 | 33 | 13 | 4 | 17 |
| 6(Y) | 23 | 38 | 15 | 7 | 22 |
| 7(Y) | 23 | 36 | 13 | 7 | 20 |

TABLE 22.—DATA CONCERNING THE RATE OF TELIAL DEVELOPMENT OF NINE PHYSIOLOGIC FORMS ON VICTORY IN THE MATURE STAGE WHEN KEPT AT A TEMPERATURE OF 16°C.

| Forms | Number of days | | | | |
|---|---|---|---|---|---|
| | From inoculation to first telial development | From inoculation to complete telial development | From first telia to complete telial development | From end of incubation period to first telial development | From end of incubation period to complete telial development |
| 1 | 23.5 | 38.5 | 15 | 11.5 | 26.5 |
| 2 | 24.5 | 39.5 | 15 | 12.5 | 27.5 |
| 3 | 17.5 | 24.5 | 7 | 5.5 | 12.5 |
| 4 | 18.5 | 27.5 | 9 | 6.5 | 15.5 |
| 5 | 24.5 | 41 | 16.5 | 12.5 | 29 |
| 6 | 20 | 30.5 | 10.5 | 8 | 18.5 |
| 7 | 18 | 29 | 11 | 6 | 17 |
| 8 | 18 | 27 | 9 | 6 | 15 |
| 9 | 17.5 | 26.5 | 9 | 5.5 | 14.5 |
| 6(Y) | 21.5 | 32.5 | 11 | 9.5 | 20.5 |
| 7(Y) | 20 | 31.5 | 11.5 | 8 | 19.5 |

TABLE 23.—DATA CONCERNING THE RATE OF TELIAL DEVELOPMENT OF NINE PHYSIOLOGIC FORMS ON VICTORY IN THE MATURE STAGE WHEN KEPT AT A TEMPERATURE OF 24°C.

| Forms | Number of days | | | | |
|---|---|---|---|---|---|
| | From inoculation to first telial development | From inoculation to complete telial development | From first telia to complete telial development | From end of incubation period to first telial development | From end of incubation period to complete telial development |
| 1 | 19 | 29.5 | 10.5 | 11 | 21.5 |
| 2 | 18 | 28.5 | 10.5 | 10 | 20.5 |
| 3 | 10 | 16.5 | 6.5 | 2 | 8.5 |
| 4 | 13 | 20 | 7 | 5 | 12 |
| 5 | 18 | 30 | 12 | 10 | 22 |
| 6 | 13.5 | 19.5 | 6 | 5.5 | 11.5 |
| 7 | 12.5 | 20.5 | 8 | 4.5 | 12.5 |
| 8 | 11.5 | 20.5 | 9 | 3.5 | 12.5 |
| 9 | 11 | 20.5 | 9.5 | 3 | 12.5 |
| 6(Y) | 14.5 | 23 | 8.5 | 6.5 | 15 |
| 7(Y) | 14.5 | 23 | 8.5 | 6.5 | 15 |

TABLE 24.—DATA CONCERNING THE RATE OF TELIAL DEVELOPMENT OF NINE PHYSIOLOGIC FORMS ON VICTORY IN THE MATURE STAGE WHEN KEPT AT A TEMPERATURE OF 28°C.

| Forms | Number of days | | | | |
|---|---|---|---|---|---|
| | From inoculation to first telial development | From inoculation to complete telial development | From first telia to complete telial development | From end of incubation period to first telial development | From end of incubation period to complete telial development |
| 1 | 12.5 | 22 | 9.5 | 3.5 | 13 |
| 2 | 12 | 23.5 | 11.5 | 3 | 14.5 |
| 3 | 9 | 14 | 5 | 0 | 5 |
| 4 | 9 | 14 | 5 | 0 | 5 |
| 5 | 11 | 21 | 10 | 2 | 12 |
| 6 | 10 | 15 | 5 | 1 | 6 |
| 7 | 10 | 15.5 | 5.5 | 1 | 6.5 |
| 8 | 10 | 15.5 | 5.5 | 1 | 6.5 |
| 9 | 9.5 | 15 | 5.5 | .5 | 6 |
| 6(Y) | 11 | 16.5 | 5.5 | 2 | 7.5 |
| 7(Y) | 10.5 | 17.5 | 7 | 1.5 | 8.5 |

In the cold section and outside the greenhouse, the incubation period of the various physiologic forms was twelve days, while in the warm section it was seven days.

Data concerning the rate of telial development of the various physiologic forms on the two hosts kept under the different environmental conditions are presented in Tables 26 to 28. Teliospore formation was more rapid on both hosts kept in the warm section (26°C.) of the greenhouse than when kept in the cold section (16°C.) or outside the greenhouse. Differences between the rates of teliospore formation of the different physiologic forms on Victory and White Russian kept under the same environmental conditions were not uniform. That is, one host could not be considered to have induced more rapid telial development in all the physiologic forms than the other when both were kept under the same conditions. The rate of formation of teliospores by the eight physiologic forms on the hosts Victory and White

TABLE 25.—DATA CONCERNING THE RATE OF TELIAL DEVELOPMENT OF THREE GROUPS OF PHYSIOLOGIC FORMS ON VICTORY IN THE MATURE STAGE WHEN KEPT AT FOUR DIFFERENT TEMPERATURES.

| Tempertures | Forms | Number of days | | | | |
|---|---|---|---|---|---|---|
| | | From inoculation to first telial development | From inoculation to complete telial development | From first telia to complete telial development | From end of incubation period to first telial development | From end of incubation period to complete telial development |
| 12°C. | 1, 2, 5 | 26.3 | 46.2 | 19.9 | 10.3 | 30.2 |
| | 3, 4, 6, 7, 8, 9 | 19.3 | 32.4 | 13.1 | 3.3 | 16.4 |
| | 6Y, 7Y | 23 | 37 | 14 | 7 | 21 |
| 16°C. | 1, 2, 5 | 24.2 | 39.7 | 15.5 | 12.2 | 27.7 |
| | 3, 4, 6, 7, 8, 9 | 18.3 | 27.5 | 9.2 | 6.3 | 15.5 |
| | 6Y, 7Y | 20.8 | 32 | 11.2 | 8.8 | 20 |
| 24°C. | 1, 2, 5 | 18.3 | 29.3 | 11 | 10.3 | 21.3 |
| | 3, 4, 6, 7, 8, 9 | 11.9 | 19.6 | 7.7 | 3.9 | 11.6 |
| | 6Y, 7Y | 14.5 | 23 | 8.5 | 6.5 | 15 |
| 28°C. | 1, 2, 5 | 11.7 | 22.2 | 10.5 | 2.7 | 13.2 |
| | 3, 4, 6, 7, 8, 9 | 9.6 | 14.8 | 5.2 | .6 | 5.8 |
| | 6Y, 7Y | 10.8 | 17 | 6.2 | 1.8 | 8 |

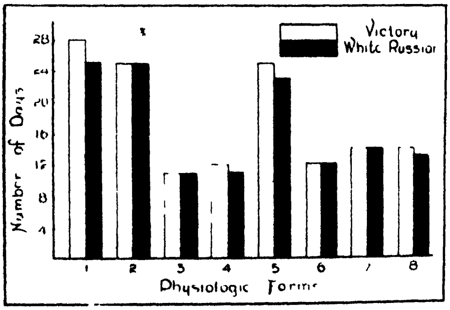
TABLE 26.—DATA CONCERNING THE RATE OF TELIAL DEVELOPMENT OF EIGHT PHYSIOLOGIC FORMS ON VICTORY AND WHITE RUSSIAN IN THE MATURE STAGE KEPT IN A SECTION OF A GREENHOUSE AT A MEAN TEMPERATURE OF 26°C.

| Forms | Hosts | Number of days | | | | |
|---|---|---|---|---|---|---|
| | | From inoculation to first telial development | From inoculation to complete telial development | From first telia to complete telial development | From end of incubation period to first telial development | From end of incubation period to complete telial development |
| 1 | Victory | 18 | 35 | 17 | 11 | 28 |
| | White Russian | 18 | 32 | 14 | 11 | 25 |
| 2 | Victory | 18 | 32 | 14 | 11 | 25 |
| | White Russian | 18 | 32 | 14 | 11 | 25 |
| 3 | Victory | 9 | 18 | 9 | 2 | 11 |
| | White Russian | 10 | 18 | 8 | 3 | 11 |
| 4 | Victory | 9 | 19 | 10 | 2 | 12 |
| | White Russian | 10 | 18 | 8 | 3 | 11 |
| 5 | Victory | 17 | 32 | 15 | 10 | 25 |
| | White Russian | 18 | 30 | 12 | 11 | 23 |
| 6 | Victory | 10 | 19 | 9 | 3 | 12 |
| | White Russian | 10 | 19 | 9 | 3 | 12 |
| 7 | Victory | 10 | 21 | 11 | 3 | 14 |
| | White Russian | 10 | 21 | 11 | 3 | 14 |
| 8 | Victory | 10 | 21 | 11 | 3 | 14 |
| | White Russian | 10 | 20 | 10 | 3 | 13 |

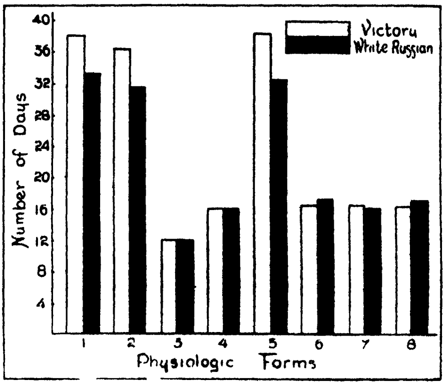
TABLE 27.—DATA CONCERNING THE RATE OF TELIAL DEVELOPMENT OF EIGHT PHYSIOLOGIC FORMS ON VICTORY AND WHITE RUSSIAN IN THE MATURE STAGE KEPT IN A SECTION OF A GREENHOUSE AT A MEAN TEMPERATURE OF 16°C.

| Forms | Hosts | Number of days | | | | |
|---|---|---|---|---|---|---|
| | | From inoculation to first telial development | From inoculation to complete telial development | From first telia to complete telial development | From end of incubation period to first telial development | From end of incubation period to complete telial development |
| 1 | Victory | 22 | 50 | 28 | 10 | 38 |
| | White Russian | 22 | 45 | 23 | 10 | 33 |
| 2 | Victory | 21 | 48 | 27 | 9 | 36 |
| | White Russian | 21 | 43 | 22 | 9 | 31 |
| 3 | Victory | 12 | 24 | 12 | 0 | 12 |
| | White Russian | 14 | 24 | 10 | 2 | 12 |
| 4 | Victory | 13 | 28 | 15 | 1 | 16 |
| | White Russian | 15 | 28 | 13 | 3 | 16 |
| 5 | Victory | 24 | 50 | 26 | 12 | 38 |
| | White Russian | 25 | 44 | 19 | 13 | 32 |
| 6 | Victory | 14 | 28 | 14 | 2 | 16 |
| | Whire Russian | 14 | 29 | 15 | 2 | 17 |
| 7 | Victory | 14 | 29 | 15 | 2 | 17 |
| | White Russian | 14 | 28 | 14 | 2 | 16 |
| 8 | Victory | 14 | 28 | 14 | 2 | 16 |
| | White Russian | 15 | 29 | 14 | 3 | 17 |

Russian kept under the different environmental conditions is compared graphically in Text Figures 17 to 19. The number of days taken by the different physiologic forms to attain complete telial development from the end of the incubation period is the index used for the comparison of their rate of



Text Figure 17. A comparison of the rate of teliospore formation by eight physiologic forms on Victory and White Russian in the mature stage kept at a mean temperature of 26°C.

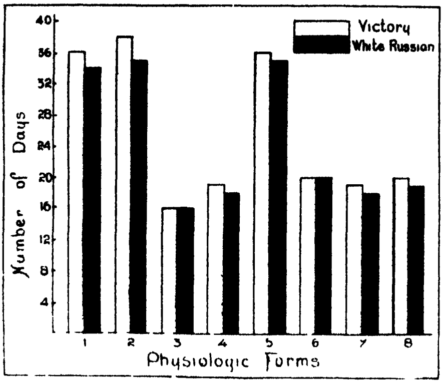


Text Figure 18. A comparison of the rate of teliospore formation by eight physiologic forms on Victory and White Russian in the mature stage kept at a mean temperature of 16°C.

TABLE 28.—DATA CONCERNING THE RATE OF TELIAL DEVELOPMENT OF EIGHT PHYSIOLOGIC FORMS ON VICTORY AND WHITE RUSSIAN IN THE MATURE STAGE KEPT OUTSIDE THE GREENHOUSE.

| Forms | Hosts | Number of days | | | | |
|---|---|---|---|---|---|---|
| | | From inoculation to first telial development | From inoculation to complete telial development | From first telia to complete telial development | From end of incubation period to first telial development | From end of incubation period to complete telial development |
| 1 | Victory | 32 | 48 | 16 | 20 | 36 |
| | White Russian | 29 | 46 | 17 | 17 | 34 |
| 2 | Victory | 31 | 50 | 19 | 19 | 38 |
| | White Russian | 32 | 47 | 15 | 20 | 35 |
| 3 | Victory | 16 | 28 | 12 | 4 | 16 |
| | White Russian | 17 | 28 | 11 | 5 | 16 |
| 4 | Victory | 16 | 31 | 15 | 4 | 19 |
| | White Russian | 18 | 30 | 12 | 6 | 18 |
| 5 | Victory | 33 | 48 | 15 | 21 | 36 |
| | White Russian | 31 | 47 | 16 | 19 | 35 |
| 6 | Victory | 18 | 32 | 14 | 6 | 20 |
| | White Russian | 19 | 32 | 13 | 7 | 20 |
| 7 | Victory | 18 | 31 | 13 | 6 | 19 |
| | White Russian | 18 | 30 | 12 | 6 | 18 |
| 8 | Victory | 20 | 32 | 12 | 8 | 20 |
| | White Russian | 19 | 31 | 12 | 7 | 19 |

telial development. There was a marked difference between the rate of formation of teliospores of forms 1, 2 and 5 and that of the other physiologic forms. Under all the different environmental conditions, forms 1, 2 and 5 formed teliospores much more slowly than did forms 3, 4, 6, 7 and 8.



Text Figure 19. A comparison of the rate of teliospore formation by eight physiologic forms on Victory and White Russian in the mature stage kept outside the greenhouse.

## DISCUSSION OF RESULTS

The results obtained from the various experiments show that temperature has a marked effect on the rate of teliospore formation by the different physiologic forms of *P. graminis avenae.* These results are in accord with those obtained by Johnson (*24*) working with physiologic forms of *P. graminis tritici.* At relatively high temperatures (24° to 28°C.), teliospore formation by all physiologic forms took place much more rapidly than at relatively low temperatures (12° to 16°C.).

The stage of development of the host was not found to be an important factor in the formation of teliospores by any of the physiologic forms at either high or low temperatures; all physiologic forms developed teliospores on both seedlings and mature plants. These results do not substantiate the conclusions of Gassner (*11*) that the development of teliospores by the cereal rusts is independent of external conditions but dependent on a certain stage of maturity of the host plant. Johnson (*24*) observed that teliospores of *P. graminis tritici* formed most rapidly at the nodes of mature plants. This was not found to be the case in *P. graminis avenae.* While teliospores generally formed first on the lower leaves it cannot be stated that any specific host tissue invariably induced the most rapid telial development of the physiologic forms of *P. graminis avenae.*

Inherent differences in the capability of certain groups of physiologic forms to form teliospores were apparent. Within the temperature range employed, forms 1, 2 and 5 developed teliospores more slowly on both seedlings and mature plants than forms 3, 4, 6, 7, 8 and 9. These results are in agreement with those obtained by Bailey (*1*), who found that forms 3 and 4 formed teliospores with greater rapidity than forms 1, 2 and 5. As forms 3 and 4 are more virulent than the latter forms, he suggested that a correlation between rapidity of teliospore formation and virulence might exist. Such a correlation is indicated by the results of the present study. Forms 3, 4, 6, 7, 8 and 9 are more virulent than forms 1, 2 and 5, and all in the former group form teliospores more rapidly than do those in the latter group.

It is of interest to note that while forms 1, 2 and 5 were the most prevalent physiologic forms occurring in Canada during the six-year period 1925-1930, forms 3, 4, 6, 7, 8 and 9 were isolated rarely (Text Figure 3). That the rarity of these virulent physiologic forms in Canada may be due to their rapid transition into the telial stage is suggested by the results of this study. Inasmuch as these virulent forms develop teliospores more rapidly than forms 1, 2 and 5, and form telia more rapidly at a high than at a low temperature, it appears probable that they may not become distributed during the summer as rapidly as forms 1, 2 and 5, owing to curtailment of urediniospore production. A further factor which may possibly limit the prevalence of these virulent physiologic forms is that the teliospores which they form during the summer, when the temperature is high, may not be germinable. In 1898, Eriksson (*6*) suggested that only the teliospores produced by certain cereal rusts during the late autumn succeed in germinating the following spring. Johnson (*24*), in 1931, found by experiments carried on in the greenhouse that the teliospores of physiologic forms of *P. graminis tritici,* when formed at high temperatures (70°-75°C.), germinated less readily than did those formed at low temperatures (55°-60°C.).

## THE RELATION OF ATMOSPHERIC HUMIDITY TO THE TELIAL DEVELOPMENT OF CERTAIN PHYSIOLOGIC FORMS

Our knowledge concerning the effect of atmospheric humidity on the formation of teliospores is limited. Certain workers, however, have noted that this factor is apparently capable of influencing the rate of telial development. As early as 1904, Smith (*41*) observed that a dry atmosphere was conducive to the rapid formation of teliospores by *P. asparagi.* Waters (*55*) was able to demonstrate by experiments that the telial development of this rust was favoured by a low atmospheric humidity. That is, teliospores were formed more rapidly when the moisture content of the air surrounding the host was low than when it was high. When wheat seedlings were infected with *P. graminis tritici* and grown under bell jars in the greenhouse, Johnson (*24*) observed that "all pustules on leaves covered by the bell jars contained teliospores, while no teliospores were present on the check plants which were uncovered". This was considered to be due possibly to the higher humidity of the air within the bell jars.

### THE FORMATION OF TELIOSPORES BY FORMS 2 AND 3 ON VICTORY IN THE SEEDLING AND MATURE STAGES WHEN KEPT AT LOW AND HIGH ATMOSPHERIC HUMIDITIES (MADISON)

The effect of atmospheric humidity on the telial development of forms 2 and 3 on the host Victory in the seedling and mature stages was investigated in this experiment. These two physiologic forms were chosen for study because of the apparently inherent difference in their capability to form teliospores. It has been shown in previous experiments that form 2 attains complete telial development much more slowly than form 3.

Seedlings and mature plants of the host Victory were inoculated with urediniospores of each of the two physiologic forms. Thirty pots of seedlings and eight pots of this host in the mature stage were inoculated with form 2 and an equal number with form 3. The pots were kept for the usual length of time in the incubation chambers before being distributed as follows. Half the number of pots inoculated at the two stages of development with each of the two physiologic forms were placed in a chamber in the greenhouse maintained at a relative humidity of 40%, and the remaining pots were kept in another chamber at a relative humidity of 80%. In both chambers, the temperature was maintained at 24°C. Observations on the formation of teliospores were made in the usual manner. Uredinia on the seedlings and the mature plants in both chambers first appeared eight days after inoculation.

It will be evident from Table 30 that both the extent and the rate of telial development of forms 2 and 3 were affected by humidity. Both physiologic forms developed teliospores on a greater percentage of the infected seedlings when kept at a high relative humidity (80%) than at a low one (40%). Teliospores formed more rapidly also on the seedlings kept at the higher humidity. The statistical analysis of the data (Table 30) obtained in this experiment shows that, for both physiologic forms, the differences in the extent and rate of telial development which occurred at the two humidities may be considered significant. The values of $\chi^2$ in all cases are equal to, or greater than, the 5% points.

The effect of atmospheric humidity on the telial development of forms 2 and 3 on mature plants was different from that on seedlings. On the mature plants the formation of teliospores by both physiologic forms took place with slightly greater rapidity at the lower relative humidity (40%), as is shown in Table 31. It might be pointed out here that the low humidity was unfavourable for the development of both the seedlings and mature plants, particularly for the latter, as these plants ripened prematurely under the conditions of a high temperature (24°C.) and a low humidity (40%).

While the experiment is not sufficiently extensive to warrant drawing final conclusions, the results at least indicate that a high relative humidity was conducive to teliospore formation on seedlings but not on mature plants.

With respect to the seedling plants, these results corroborate those of Johnson (*24*), and for the mature plants, they seem to confirm the findings of Smith (*41*) and Waters (*55*).

### THE EFFECT OF ULTRA-VIOLET RADIATION ON THE UREDINIAL AND TELIAL DEVELOPMENT OF CERTAIN PHYSIOLOGIC FORMS

Ultra-violet radiation has been shown in the past to have a profound effect on the development of various fungi. A number of workers (*21*, *37*, *39*, *47*, *48*, *49*, *50*) have observed that it is capable of producing striking effects on the development of both the asexual and sexual stages of certain species. Fulton and Coblenz (*10*) have shown that ultra-violet rays possess definite fungicidal properties, spores being killed after a comparatively short exposure to such rays. Some spores, however, could survive longer exposures than others, and this was attributed to the protective colouration or composition of the spore-wall. Growing mycelium was stated to be more easily killed than ungerminated spores. Weston and Halnan (56) found that in many cases the mycelium was not killed but, instead, growth was inhibited for some considerable time.

Weston (*57*, *58*, *59*, *60*) has recently studied the behaviour of a number of disease organisms under different conditions of light. Urediniospores of different physiologic forms of *P. graminis tritici* and *P. graminis avenae* were found to be incapable of germination under strong sunlight. When the

TABLE 30.—THE FORMATION OF TELIOSPORES BY FORMS 2 AND 3 ON VICTORY IN THE SEEDLING STAGE AT RELATIVE HUMIDITIES OF 40 AND 80 PER CENT.

| Forms | Relative humidity Per cent | Extent of telial development: Percentage of infected plants bearing telia | $\chi^2$ | 5 per cent point | Rate of telial development: Number of days taken to form telia | $\chi_2$ | 5 per cent point |
|---|---|---|---|---|---|---|---|
| 2 | 40 | 28.0 | 40.4 | 3.8 | 5.1 | 6.0 | 6.0 |
|  | 80 | 63.6 |  |  | 4.1 |  |  |
| 3 | 40 | 79.6 | 26.0 | 3.8 | 5.9 | 34.5 | 6.0 |
|  | 80 | 97.2 |  |  | 3.9 |  |  |

TABLE 31.—THE FORMATION OF TELIOSPORES BY FORMS 2 AND 3 ON VICTORY IN THE MATURE STAGE AT RELATIVE HUMIDITIES OF 40 AND 80 PER CENT.

| Forms | Relative humidity Per cent | Number of days |  |  |  |  |
|---|---|---|---|---|---|---|
|  |  | From inoculation to first telial development | From inoculation to complete telial development | From first telia to to complete telial development | From end of incubation period to first telial development | From end of incubation period to complete telial development |
| 2 | 40 | 15 | 24 | 9 | 7 | 16 |
|  | 80 | 16 | 26 | 10 | 8 | 18 |
| 3 | 40 | 10 | 17 | 7 | 2 | 9 |
|  | 80 | 11 | 19 | 8 | 3 | 11 |

urediniospores were covered by Wratten light filters and exposed to sunlight, abundant germination took place under the green and blue filters but only occasionally did any spores germinate under the red, scarlet, orange, yellow and purple filters. The germination of the urediniospores of *P. graminis tritici* was also found to be greatly reduced when these spores were subjected to ultra-violet rays produced by a quartz mercury-vapour lamp.

The following experiments were undertaken to determine whether or not ultra-violet rays affected the uredinial or telial development of physiologic forms of *P. graminis avenae.*

### MATERIALS

In the experiments at Winnipeg, the source of light was a quartz mercury-vapour lamp. This was the Home Model Alpine Sun Lamp (alternating current, 110 volts, 60 cycle), manufactured by the Hanovia Chemical and Manufacturing Company, Newark, New Jersey. In the experiments at Madison, the source of light was a Burdick Sun Lamp, manufactured by the Burdick Corporation, Milton, Wisconsin.

### EXPERIMENTS AT WINNIPEG

To investigate the effect of ultra-violet light on the uredinial development of forms 1 and 2, twenty-five pots of seedlings of each of the hosts, Victory, White Russian, Richland and Joanette Strain, were inoculated with urediniospores of form 1, and the same number of pots of each host with form 2. After inoculation, the various pots of seedlings were kept for the usual period of time in the incubation chambers. As soon as the plants had dried after removal from the chambers, they were subjected to treatment. Of the pots inoculated with form 1, five of each were kept as checks, and the remaining twenty of each host were divided into four equal lots. One lot of each host was irradiated for 15 minutes, a second for 30, a third for 60 and the fourth lot for 90 minutes at a distance of 42 inches from the source of the light. The

TABLE 32.—THE TYPES OF UREDINIAL INFECTION PRODUCED BY TWO PHYSIOLOGIC FORMS ON FOUR HOSTS WHEN IRRADIATED WITH ULTRA-VIOLET LIGHT.

| Forms | Hosts | Checks | Irradiated | | | |
|---|---|---|---|---|---|---|
| | | | 15 minutes | 30 minutes | 60 minutes | 90 minutes |
| 1 | Victory | 45/45(4) | 40/40(4)– | 40/40(4) | 42/42(4) | 41/41(4) |
| | White Russian | 48/48(3)c̄ | 41/41(3)c̄ | 46/46(3)c̄ | 42/42(3)c̄ | 50/50(3)c̄ |
| | Richland | 57/58(2)c̿ | 43/43(2)– | 50/50(2)c̄ | 43/45(2)– | 53/53(2)– |
| | Joanette Strain | $\frac{5(x)-9(1);23}{40}$ | $\frac{2(x)-18(1)-;20}{40}$ | $\frac{3(x)21(1)-;17}{40}$ | $\frac{6(x)-18(1)-;24}{50}$ | $\frac{4(x)-23(1)-;20}{47}$ |
| 2 | Victory | 42/42(4) | 46/46(4) | 40/40(4)– | 46/47(4) | 45/45(4) |
| | White Russian | 48/48(3)c̄ | 44/44(3)c̄ | 46/46(3)c̄ | 52/52(3)c̄ | 50/50(3)c̄ |
| | Richland | 41/42(2)– | 54/54(2)– | 53/53(2)– | 46/46(2)– | 47/47(2)– |
| | Joanette Strain | 46/46(4) | 47/47(4) | 43/44(4) | 47/47(4) | 49/49(4)– |

TABLE 33.—DATA CONCERNING THE FORMATION OF TELIOSPORES BY FORMS 1, 2, 3 AND 4 ON VICTORY IN THE SEEDLING STAGE WHEN IRRADIATED WITH ULTRA-VIOLET LIGHT

| Forms | Treatments | Percentage of infected seedlings bearing telia | $\chi^2$ | 5 per cent point | Mean number of days taken to form telia | $\chi^2$ | 5 per cent point |
|---|---|---|---|---|---|---|---|
| 1 | Check | 70.9 | 2.2 | 9.5 | 3.4 | 7.9 | 9.5 |
| | 15 minutes | 76.6 | | | 4.0 | | |
| | 30 " | 76.2 | | | 3.7 | | |
| | 60 " | 77.3 | | | 3.2 | | |
| | 90 " | 71.8 | | | 3.3 | | |
| | Check | 70.9 | .9 | 3.8 | 3.4 | 2.2 | 3.8 |
| | All treatments | 75.9 | | | 3.5 | | |
| 2 | Check | 79.1 | 7.8 | 9.5 | 3.8 | 6.5 | 9.5 |
| | 15 minutes | 72.4 | | | 4.8 | | |
| | 30 " | 77.4 | | | 4.5 | | |
| | 60 " | 77.3 | | | 4.1 | | |
| | 90 " | 75.7 | | | 4.4 | | |
| | Check | 79.1 | 2.8 | 3.8 | 3.8 | 2.9 | 3.8 |
| | All treatments | 75.7 | | | 4.4 | | |
| 3 | Check | 99.1 | 6.7 | 9.5 | 1.8 | 9.3 | 9.5 |
| | 15 minutes | 99.0 | | | 2.5 | | |
| | 30 " | 99.2 | | | 1.9 | | |
| | 60 " | 95.8 | | | 1.7 | | |
| | 90 " | 99.1 | | | 1.7 | | |
| | Check | 99.1 | .5 | 3.8 | 1.8 | .6 | 3.8 |
| | All treatments | 98.3 | | | 1.9 | | |
| 4 | Check | 94.2 | 2.4 | 9.5 | 2.8 | 3.9 | 9.5 |
| | 15 minutes | 88.8 | | | 3.3 | | |
| | 30 " | 90.7 | | | 3.6 | | |
| | 60 " | 91.4 | | | 3.0 | | |
| | 90 " | 93.0 | | | 3.3 | | |
| | Check | 94.2 | | | 2.8 | | |
| | All treatments | 91.0 | 1.1 | 3.8 | 3.3 | 1.5 | 3.8 |

pots inoculated with form 2 were given similar disposition. The checks as well as the treated pots were placed in the same section of the greenhouse, the mean temperature of which was 15°C. during the experiment.

The types of uredinial infection produced by forms 1 and 2 on the check and irradiated seedlings are shown in Table 32. There was no appreciable difference in the uredinial development of either of the two physiologic forms on any of the hosts, whether irradiated or not. The seedlings irradiated for 90 minutes, however, showed definite signs of injury. The injury to the seedlings made itself apparent in the dessication of the tip and margin of the leaves. Uredinia on the uninjured parts of the leaves were in no way different from those produced on uninjured seedlings. Differences in the sensitivity of the four hosts to the ultra-violet light were not observed.

In an experiment to determine whether or not ultra-violet light affected the telial development in *P. graminis avenae* 100 pots of Victory in the seedling stage were divided into four sets of 25 pots each and inoculated with urediniospores of form 1, 2, 3 and 4, a different form being used for each set. This experiment was repeated. After inoculation the procedure followed was essentially the same as that stated in the previous experiment. All the pots of seedlings were kept in a section of the greenhouse, the mean temperature of which was 24°C. during the experiment. The incubation period of the different physiologic forms was seven days, regardless of the length of exposure of the plants to the ultra-violet light.

A statistical analysis of the results of this experiment is presented in Table 33. There were no significant differences between the extent or the rate of telial development which occurred on the check and on any of the treated seedlings. The values of $\chi^2$ are larger in all cases than those of the 5% points. These results are in agreement with those of Weston (*59*), who found that ultra-violet light did not hasten the formation of teliospores in *P. coronata*.

## EXPERIMENTS AT MADISON

The effect of ultra-violet light on the uredinial development of forms 3, 4 and 5 as well as of forms 1 and 2 was investigated at Madison, but in this experiment, Joanette Strain in the seedling and mature stages alone was used as a host. One set of eight pots of seedling plants and two pots of mature plants of this host were inoculated with urediniospores of form 1; a similar set was inoculated with form 2, and so on for forms 3, 4 and 5. Following inoculation, the various pots were kept for 48 hours in the incubation chambers. On removal, they were placed in a controlled chamber maintained at a temperature of 16°C. and a relative humidity of 75%. Four pots of seedlings and one pot of mature plants from each set were irradiated for one hour each day until final records on uredinial development were taken, the lamp being placed 36 inches from the plants. The remaining pots were kept as checks.

The results of this experiment are presented in Tables 34 and 35. It will be noted that the types of uredinial infection produced by the different physiologic forms on the irradiated plants were not appreciably different from those produced on the check plants. There was also no difference between the incubation period of the forms on the irradiated and the check plants.

To ascertain what effect ultra-violet light had on the telial development of forms 2 and 3 on Victory in the mature stage, six pots of this host in the mature stage were inoculated with urediniospores of form 2, and six similar pots with form 3. The pots were then kept for 48 hours in the incubation chambers. On removal, the pots were placed in a controlled chamber maintained at a temperature of 24°C. and a relative humidity of 75%. Three pots of each set were irradiated, and three were kept as a check. The plants were irradiated in the same manner and for the same length of time as in the last mentioned experiment.

The results of this experiment are presented in Table 36. The rate of teliospore formation in form 3 on the irradiated was identical to that on the check plants, and there was but little difference in the rate of teliospore formation in form 2 on the irradiated and the check plants.

From these experiments it is evident that the rust organism within the plant tissue is not appreciably affected by exposure to ultra-violet light of an intensity which is not lethal or seriously injurious to the host. The results

TABLE 34.—THE TYPES OF UREDINIAL INFECTION PRODUCED BY FIVE PHYSIOLOGIC FORMS ON JOANETTE STRAIN IN THE SEEDLING STAGE WHEN IRRADIATED WITH ULTRA-VIOLET LIGHT.

| Forms | Types of uredinial infection | |
|---|---|---|
| | Produced on check seedlings | Produced on irradiated seedlings |
| 1 | $\frac{3(1)-;30}{35}$ | $\frac{1(1)-;31}{34}$ |
| 2 | 33/33(4) | 39/39(4) |
| 3 | $\frac{1(1);34}{35}$ | $\frac{2(1);33}{35}$ |
| 4 | $\frac{5(1)\pm\ ;30}{35}$ | $\frac{6(1)\pm 2(x)=\ ;30}{38}$ |
| 5 | $\frac{2(1)\pm 2(x)=\ ;31}{36}$ | $\frac{3(1)\pm\ ;34}{37}$ |

TABLE 35.—THE TYPES OF UREDINIAL INFECTION PRODUCED BY FIVE PHYSIOLOGIC FORMS ON JOANETTE STRAIN IN THE MATURE STAGE WHEN IRRADIATED WITH ULTRA-VIOLET LIGHT.

| Forms | Types of uredinial infection | |
|---|---|---|
| | Produced on check seedlings | Produced on irradiated seedlings |
| 1 | $\frac{2(1)\pm 2(x)=\ ;6}{10}$ | $\frac{2(1)\pm 2(x)=\ ;5}{9}$ |
| 2 | 10/10(4)c | 10/10(4)c |
| 3 | $\frac{2(1)\pm\ ;8}{10}$ | $\frac{2(1)\pm\ ;9}{11}$ |
| 4 | $\frac{5(1)\pm 1(x)=\ ;4}{10}$ | $\frac{2(1)\pm\ ;8}{10}$ |
| 5 | $\frac{2(1)\pm 4(x)=\ ;4}{10}$ | $\frac{2(1)\pm 3(x)-;5}{10}$ |

TABLE 36.—DATA CONCERNING THE RATE OF TELIAL DEVELOPMENT OF FORMS 2 AND 3 ON VICTORY IN THE MATURE STAGE WHEN IRRADIATED WITH ULTRA-VIOLET LIGHT.

| Forms | Treatments | Number of days | | | | |
|---|---|---|---|---|---|---|
| | | From inoculation to first telial development | From inoculation to complete telial development | From first telial to complete telial development | From end of incubation period to first telial development | From end of incubation period to complete telial development |
| 2 | Check | 14 | 23 | 9 | 6 | 15 |
| | Irradiated | 13 | 24 | 11 | 5 | 16 |
| 3 | Chec | 10 | 16 | 6 | 2 | 8 |
| | Irradiated | 10 | 16 | 6 | 2 | 8 |

of these experiments are in accord with those of Fulton and Coblenz (*10*) who found that ultra-violet light is unable to penetrate much, if any, below the surface of fruits. Apparently the ultra-violet rays do not penetrate plant tissue to any appreciable distance.

## SUMMARY

1. Nine physiologic forms of *P. graminis avenae* were isolated from 1070 collections of oat stem rust in Canada during the six-year period, 1925-1930. These are forms 1, 2, 3, 4, 5, 6, 7, 8 and 9. During 1931, forms 6 and 7, yellow in colour, were isolated from cultures obtained from a barberry which had been artificially inoculated. Of the 1257 isolations made in Canada during the period mentioned, 1213, or 96.5%, consisted of forms 1, 2 and 5.

2. The relation of certain environmental factors, particularly temperature, to the development of the uredinial and telial stages of the various physiologic forms has been studied. The various studies were carried on, with few exceptions, at controlled temperarures within the range 12° to 28°C.

3. It has been shown that the temperature at which the hosts Victory, White Russian, Richland and Joanette Strain are grown prior to inoculation in the seedling stage has no appreciable effect on the types of uredinial infection produced on them later by forms 1, 2, 3, 4 and 5.

4. No significant changes were induced by temperature in the types of uredinial infection produced by forms 2, 6, 7, 8 and 9 on the hosts Victory, White Russian, Richland and Joanette Strain. Similarly, no appreciable differences due to temperature were observed in the types of uredinial infection produced by forms 1, 3, 4 and 5 on the hosts Victory, White Russian and Richland.

5. The types of uredinial infection produced by forms 1, 3, 4 and 5 on the differential host, Joanette Strain, were profoundly changed by temperature.

6. Certain physiologic forms can be distinguished from one another only on Joanette Strain and only when this host is kept at a relatively low temperature (12°C.); when it is kept at a high temperature (28°C.), these particular physiologic forms are indistinguishable. To obviate the necessity of maintaining accurately controlled temperatures while the identification of the physiologic forms present in a large number of collections of oat stem-rust is in progress, the following grouping of the forms, distinguishable only on Joanette Strain at a low temperature, is suggested: Group I, forms 1, 2 and 5; Group II, forms 3 and 7; Group III, forms 4 and 6.

7. Temperature has been shown to be an important factor in the formation of teliospores in *P. graminis avenae.*

8. All the physiologic forms developed teliospores more rapidly on both seedlings and mature plants at relatively high (24° to 28°C.) than at low temperatures (12° to 16°C.).

9. Forms 3, 4, 6, 7, 8 and 9 were found to form teliospores much more rapidly than forms 1, 2 and 5. Since the former group of physiologic forms is more virulent than the latter, a correlation between pathogenicity and rapidity of teliospore formation is indicated.

10. It is suggested that the rarity of forms 3, 4, 6, 7, 8 and 9 in Canada may be due to the early development of telia. Thus the uredinial period is reduced and, as a consequence, the amount of inoculum is greatly diminished.

11. The stage of development of the host was not shown to be a limiting factor in the formation of teliospores by any of the physiologic forms.

12. A high relative humidity (80%) was found to increase both the extent and the rate of telial development on seedlings, while the rate of telial development on mature plants was slightly increased by a low relative humidity (40%).

13. Ultra-violet radiation produced no significant changes in the uredinial or telial development of the physiologic forms.

## ACKNOWLEDGMENTS

The writer wishes to express his gratitude to Dr. James G. Dickson of the Department of Plant Pathology, University of Wisconsin, for many helpful suggestions given during the progress of this study. He also wishes to acknowledge the help received from Dr. J. H. Craigie of the Dominion Rust Research Laboratory, Winnipeg, in the preparation of the manuscript. The assistance of Mr. Eugene Herrling of the Department of Plant Pathology, University of Wisconsin, in taking photographs presented in Plates III to V, is gratefully acknowledged.

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# THE ECONOMIC SITUATION

### PREPARED IN THE AGRICULTURAL ECONOMICS BRANCH DEPARTMENT OF AGRICULTURE OTTAWA FROM BASIC DATA COLLECTED BY THE DOMINION BUREAU OF STATISTICS

Wholesale prices in Canada receded in October. The index number computed by the Dominion Bureau of Statistics was 67.9 as compared with 68.9 in September, a decline of one point. Declines were registered in both the vegetable products and animal products groups. Fibres, textiles and textile products were also lower, whereas wood, wood products and paper, iron and its products and non-metallic minerals were higher. Non-ferrous metals, chemicals and allied products were lower.

*Retail Prices.*—The total index of retail prices receded from 78.8 in September to 77.9 in October. The food index declined from 65.9 to 65.4. The fuel index rose slightly but the rent index dropped from 84.0 to 80.4. This index is computed in May and October.

*Employment.*—Employment conditions again showed improvement; the index rose from 86.9 in September to 88.4 in October. The improvement was general except in the Prairie Provinces. The chief gains in employment were in the building trades and in highway construction. Employment increased in mining and logging as well but in manufacturing there was a slight recession.

*Physical Volume of Business.*—The index of physical volume of business was slightly lower in October when the index was 88.2 as compared with 90.8 in September. Industrial production was also down; the indexes for the respective months were 87.4 and 90.2. Mineral production advanced from 108.8 in September to 117.7 in October. The index of manufacturing moved downward from 97.0 in September to 87.9 in October. Construction increased as did eclctric power production. Car loadings were lower. Both imports and exports were higher.

*Agricultural Products.*—Prices of Canadian farm products on the whole moved downward in October. The total index fell from 54.7 in September to 51.4 in October. Relatively animal products lost less ground than field products. Declines in the prices of wheat, barley, oats and rye affected the index of prices of field products and this index fell from 49.5 in September to 44.6 in October. In the case of animal products, supplies were not unusually large but the quality was not high and the market weak; the index, therefore, eased down from 63.4 in September to 62.8 in October. The index of agricultural marketings in October declined from 101.1 to 70.5. There was a lower movement of wheat, barley, oats and flax to the head of the lakes and the index of grain marketings fell from 106.2 to 70.0. Live stock marketings were relatively lower than in September. Shipments of cattle were higher, the index advancing from 54.8 to 56.2. The index of marketings of calves dropped from 104.7 to 102.7. The hog index fell from 108.9 to 93.6 and that for sheep from 126.8 to 98.8.

Cold storage holdings were slightly lower, the index moving to 112.7 as at October 1. Supplies of butter, eggs, lard and veal increased whereas stocks of cheese and pork held about even while those of beef, mutton and poultry were lower than in September.

*World Trade.*—Mr. J. A. MacLeod, General Manager, The Bank of Nova Scotia, discussed the shrinkage of world trade, at the recent Annual Meeting of the Canadian Bankers' Association. He said in part: "Neglecting the statistics of value (which reflect the fall in prices of commodities, that has occurred all over the world, as well as the decline in the volume of transactions), and confining myself entirely to statistics of volume of trade, I find that, since the beginning of the depression, no less than three-eighths of the world's trade has ceased to exist. We are attempting, at present, to carry on with a volume of merchandise trade between the nations of the world, little more than 60 per cent as large as was the volume of trade in the twelve months

ANNUAL AND MONTHLY INDEX NUMBERS OF PRICES AND PRODUCTION COMPUTED BY DOMINION BUREAU OF STATISTICS

| Year | Wholesale Prices 1926 = 100 | | | | Retail prices and cost of services (5) | Production (6) 1926 = 100 | | | |
|---|---|---|---|---|---|---|---|---|---|
| | All commodities (1) | Farm products (2) | Field products (3) | Animal products (4) | | Physical volume of business | Industrial production | Agricultural marketings | Cold Storage holdings |
| 1913.... | 64.0 | 62.6 | 56.4 | 77.0 | 65.4 | .... | .... | .... | .... |
| 1914.... | 65.5 | 69.2 | 64.9 | 79.0 | 66.0 | .... | .... | .... | .... |
| 1915.... | 70.4 | 77.7 | 76.9 | 79.2 | 67.3 | .... | .... | .... | .... |
| 1916.... | 84.3 | 89.7 | 88.4 | 92.3 | 72.5 | .... | .... | .... | .... |
| 1917.... | 114.3 | 130.0 | 134.3 | 119.6 | 85.6 | .... | .... | .... | .... |
| 1918.... | 127.4 | 132.9 | 132.0 | 134.7 | 97.4 | .... | .... | .... | .... |
| 1919.... | 134.0 | 145.5 | 142.4 | 152.5 | 107.2 | 71.3 | 65.5 | 48.1 | 47.1 |
| 1920.... | 155.9 | 161.6 | 166.5 | 149.9 | 124.2 | 75.0 | 69.9 | 52.6 | 94.2 |
| 1921.... | 110.0 | 102.8 | 100.3 | 108.5 | 109.2 | 66.5 | 60.4 | 65.2 | 86.4 |
| 1922.... | 97.3 | 86.7 | 81.3 | 99.1 | 100.0 | 79.1 | 76.9 | 82.6 | 82.6 |
| 1923.... | 98.0 | 79.8 | 73.3 | 95.1 | 100.0 | 85.5 | 83.8 | 91.4 | 87.8 |
| 1924.... | 99.4 | 87.0 | 82.6 | 97.2 | 98.0 | 84.6 | 82.4 | 102.5 | 114.6 |
| 1925.... | 102.6 | 100.4 | 98.1 | 105.7 | 99.3 | 90.9 | 89.7 | 97.2 | 108.9 |
| 1926.... | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| 1927.... | 97.7 | 102.1 | 99.9 | 105.7 | 98.4 | 106.1 | 105.6 | 103.6 | 110.0 |
| 1928.... | 96.4 | 100.7 | 92.6 | 114.3 | 98.9 | 117.3 | 117.8 | 146.7 | 112.8 |
| 1929.... | 95.6 | 100.8 | 93.8 | 112.5 | 99.9 | 125.5 | 127.4 | 101.1 | 109.6 |
| 1930.... | 86.6 | 82.3 | 70.0 | 102.9 | 99.2 | 109.5 | 108.0 | 103.0 | 128.4 |
| 1931.... | 72.2 | 56.3 | 43.6 | 77.6 | 89.6 | 93.5 | 90.4 | 99.0 | 125.7 |
| 1932.... | 66.7 | 48.4 | 41.1 | 60.7 | 81.4 | 78.7 | 74.0 | 114.3 | 120.1 |
| 1933 | | | | | | | | | |
| Jan..... | 63.9 | 43.6 | 35.1 | 57.9 | 79.1 | 68.1 | 62.2 | 56.1 | 112.0 |
| Feb..... | 63.6 | 43.0 | 36.0 | 54.7 | 78.4 | 67.0 | 60.9 | 76.5 | 127.6 |
| Mar..... | 64.4 | 44.7 | 38.0 | 56.0 | 77.8 | 68.4 | 62.5 | 129.0 | 135.8 |
| April... | 65.4 | 46.8 | 41.1 | 56.4 | 78.1 | 69.8 | 65.1 | 104.1 | 112.7 |
| May.... | 66.9 | 51.2 | 46.9 | 58.4 | 77.0 | 76.4 | 72.7 | 95.4 | 100.4 |
| June.... | 67.6 | 52.6 | 49.4 | 57.9 | 77.0 | 82.2 | 79.8 | 221.9 | 119.9 |
| July.... | 70.5 | 60.1 | 60.8 | 59.0 | 77.2 | 84.1 | 82.6 | 136.3 | 114.5 |
| Aug..... | 69.4 | 57.0 | 54.9 | 60.5 | 78.6 | 89.8 | 89.5 | 197.2 | 114.2 |
| Sept.... | 68.9 | 54.7 | 49.5 | 63.4 | 78.2 | 90.8 | 90.2 | 101.1 | 115.7 |
| Oct..... | 67.9 | 51.4 | 44.6 | 62.8 | 77.9 | 88.2 | 87.4 | 70.5 | 112.7 |

1. See Prices and Price Indexes 1913-1928, pp. 19-21, 270-289 and 1913-1931, p. 15.

2. Wholesale prices of Canadian products of farm origin only. See Prices and Price Indexes 1913-1931, p. 33, and Monthly Mimeographs 1932 and 1933.

3. Wholesale prices of grains, fruits and vegetables.

4. Wholesale prices of Animals and Animal Products.

5. Including foods, rents, fuel, clothing and sundries, See Prices and Price Indexes 1913-1928, pp. 181-185, 290-293. 1926 = 100.

Prices and Price Indexes 1913-1931, pp. 122, and Monthly Mimeographs 1932-1933.

6. Monthly Review of Business Statistics, pp 8, and Monthly Indexes of the Physical volume of business in Canada, supplement to the Monthly Review of Business Statistics, November, 1932.

ending with September, 1929" This information was based upon data from nighteen countries representing about three-quarters of the world's commerce. National self sufficiency has progressed rapidly during the past five years.

*Farm Prices in United States.*—Indexes published by the Bureau of Agricultural Economics indicate that farm prices held even in October. The index was 70. The index of prices of grains declined 10 points. That of fruits and vegetables dropped from 101 to 86. The index of prices of meat animals advanced from 62 in September to 63 in October. The index of dairy products advanced 2 points and egg prices rose sharply from 77 to 94. The index of prices paid by farmers for commodities purchased remained stationary at 116. These index numbers are constructed on a base period consisting of the five-year average, August 1909 to July 1914 = 100.

The potato crop in United States is reported to be short, amounting to 2½ bushels per capita which is the lowest production recorded in 43 years, and the Bureau of Agricultural Economics anticipated an advance in price. Both the beef cattle and dairy industries are feeling the effect of heavy supplies, but sheep production is tending downward and lambs and wool have enjoyed better prices. Wheat prices in United States though higher than a year ago are still affected by large world stocks, high production and import restrictions in many European Countries.

## LA SITUATION ECONOMIQUE

PREPARE PAR LA DIVISION DE L'ECONOMIE AGRICOLE DU MINISTERE DE L'AGRICULTURE, OTTAWA, ET BASE SUR LES DONNEES RECUEILLIES PAR LE BUREAU FEDERAL DE LA STATISTIQUE

Une baisse des prix du gros au Canada s'est produite en octobre. L'indice computé par le Bureau fédéral de la Statistique était de 67.9 contre 68.9 en septembre, soit une diminution de 1 point. Il y a eu diminution également dans les groupes des produits végétaux et des produits animaux. Les fibres, les matières textiles et les produits textiles ont rétrogradé tandis que le bois, les produits du bois et le papier, le fer et ses produits et les minéraux non-métalliques montaient. Les métaux non-ferreux, les produits chimiques et de même nature étaient plus faibles.

*Prix de détail.*—L'indice total des prix du détail qui était à 78.8 en septembre est tombé à 77.9 en octobre. L'indice des vivres a baissé de 65.9 à 65.4. L'indice du combustible s'est élevé légèrement tandis que l'indice des loyers tombait de 84.0 à 80.4. Cet indice est computé en mai et en octobre.

*Embauchage.*—Les conditions du travail continuent à s'améliorer. L'indice qui était de 86.9 en septembre est passé à 88.4 en octobre. L'amélioration est générale, sauf dans les Provinces des Prairies. Les industries qui ont fait le plus de progrès sont celles du bâtiment et de la construction des grands chemins. L'embauchage a augmenté dans les industries minière et forestière mais il y a eu une légère rétrogression dans l'industrie manufacturière.

*Volume physique des affaires.*—L'indice du volume physique des affaires était un peu moins élevé en octobre (88.2 contre 90.8 en septembre). La production industrielle a également fléchi: les indices respectifs pour les mêmes mois étaient les suivants 87.4 et 90.2. Par contre, la production minérale qui était à 108.8 en septembre est montée à 117.7 en octobre. L'indice des produits manufacturés après avoir atteint 97.0 en septembre est tombé à 87.9 en octobre. La construction a progressé, de même que la production d'énergie électrique. Les chargements de wagons étaient moins nombreux. Les importations et les exportations étaient plus élevées.

*Produits agricoles.*—Les prix des produits agricoles canadiens ont en général baissé en octobre. L'indice total qui était à 54.7 en septembre est tombé à 51.4 en octobre. Les prix des produits animaux ont perdu relativement moins de terrain que ceux des produits des champs. Les baisses qui se sont produites dans les prix du blé, de l'orge, de l'avoine et du seigle ont affecté l'indice des produits des champs, lequel, de 49.5 qu'il était en septembre, est tombé à 44.6 en octobre. En ce qui concerne les produits animaux, les approvisionnements n'étaient pas beaucoup plus abondants que d'habitude mais la qualité laissait à désirer et le marché était faible. C'est pourquoi l'indice est descendu de 63.4 en septembre à 62.8 en octobre. L'indice d'octobre des ventes agricoles est tombé de 101.1 à 70.5. Les transports de blé, d'orge, d'avoine et de lin ont diminué à la tête des Grands Lacs et l'indice des ventes de grain est tombé de 106.2 à 70.0. Les ventes de bestiaux ont été relativement plus faibles qu'en septembre. Les expéditions de bovins étaient plus nombreuses, l'indice passant de 54.8 à 56.2. L'indice des ventes de veaux est tombé de 104.7 à 102.7 celui des porcs de 108.9 à 93.6 et celui des moutons de 126.8 à 98.8.

La quantité de produits entreposés au froid a un peu diminué, l'indice atteignait 112.7 au 1er octobre. Les approvisionnements de beurre, d'oeufs, de saindoux et de veau ont augmenté tandis que les stocks de fromage et de porc restaient à peu près stationnaires et que ceux de boeuf, de mouton et de volailles étaient inférieurs à ceux de septembre.

*Le commerce mondial.*—A la dernière réunion annuelle de l'Association des Banquiers canadiens, M. J. A. MacLeod, Gérant Général de la Banque de la Nouvelle Ecosse, a parlé du ralentissement du commerce mondial et a dit à ce sujet: "Laissant de côté la statistique de la valeur (qui réflète la baisse qui s'est produite dans les prix des marchandises dans le monde entier ainsi que la diminution du volume des stocks) et ne prenant que la statistique du volume du commerce, je trouve que depuis le commencement de la dépression les trois huitièmes au moins du commerce mondial ont disparu. Le commerce des marchandises qui se fait actuellement entre les nations du monde n'est guère plus de 60 p.c. de ce qu'il était dans les douze mois qui ont suivi septembre 1929." Ces renseignements sont basés sur les données fournies par dix-neuf pays, représentant les trois quarts du commerce du monde. En ces cinq dernières années les nations ont fait un grand progrès dans l'art de se suffire à elles-mêmes.

*Les prix de la ferme aux Etats-Unis.*—Les indices publiés par le Bureau de l'Economie agricole indiquent que les prix de la ferme se sont maintenus en octobre. L'indice est à 70. L'indice des prix des grains a baissé de 10 points. Celui des fruits et des légumes a baissé de 101 à 86. L'indice des prix des animaux à viande est passé de 62 en septembre à 63 en octobre. L'indice des produits laitiers est monté de 2 points. Celui des oeufs s'est élevé brusquement de 77 à 94. L'indice des prix payés par les cultivateurs pour les produits qu'ils achètent est resté stationnaire, à 116. Ces chiffres indices sont calculés sur une période de base, dans laquelle a moyenne de cinq ans, août 1909 à juillet 1914, est representée par le chiffre 100.

Aux Etats-Unis la récolte de pommes de terre est déficitaire, se montant à 2½ boisseaux par tête; c'est la plus faible production que l'on ait enregistrée depuis 43 ans, et le Bureau de l'Economie agricole prédit une hausse de prix. L'élevage des boeufs de boucherie et l'industrie laitière se ressentent des approvisionnements abondants, mais la production du mouton est en baisse et les prix des agneaux et de la laine ont remonté. Les prix du blé aux Etats-Unis, quoique un peu plus élevés que l'année dernière, sont encore affectés par les gros stocks mondiaux, les fortes productions et les restrictions imposées par beaucoup de pays européens importateurs.

## RESUME DES ARTICLES PUBLIES EN ANGLAIS DANS CE NUMERO

**La Relation des Services Agricoles aux Conditions Variantes.** Sir E. John Russell, Directeur de la Station agronomique de Rothamsted, Harpenden, Herts, Angleterre.

On donne un exposé des changements survenus dans l'agriculture qui ont rendu nécessaire en Angleterre l'adoption d'un système réparti d'importation de denrées alimentaires. On appuie sur le besoin de recherches scientifiques pour l'extension de l'agriculture, particulièrement aù l'on fait de la culture spécialisée, étant donné que le spécialiste est plus exposé à perdre ses revenus que le cultivateur ordinaire. Il est déclaré que les produits canadiens les plus recherches en Angleterre sont le blé, le fromage et les pommes.

**Quelques Aspects des Marches D'Outremer pur le Miel Canadien.** J. K. Galbraith, Université de la Californie, Berkeley, Cal.

L'Allemagne et le Royaume-Uni sont les deux principaux pays importateurs. Les perspectives pour le miel canadien sur le marché allemand ne sont pas favorables s'il s'agit d'une période limitée, mais sont meilleures s'il s'agit d'une période plus longue. Sur le marché britannique le Canada occupe une position relativement favorable. Le maintien de cette position requierera cependant la poursuite d'un système progressif de ventes.

ETUDES ABREGEES SUR LA BACILLE CALMETTE-GUERIN (B.C.G.) ET LA VACCINATION CONTRE LA TUBERCULOSE. E. A. Watson, Institut de recherches sur les maladies animales, Hull, P.Q.

L'on a trouvé que le vaccin B.C.G. ne protégeait pas le bétail contre la tuberculose, quoique au cours de leurs premieres années, a tuberculose se développait d'une façon plus lente chez les animaux vaccinés, indiquant ainsi un certain degré de résistance.

UNE ETUDE DU RAPPORT DE L'ENVIRONNEMENT SUR LE DEVELOPPEMENT DES PHASES UREDINIALES ET TELIALES DES FORMES PHYSIOLOGIQUES DE *Puccinia Graminis Avenae* ERIKKS. ET HENN. W. L. Gordon, Dominion Rust Research Laboratory, Winnipeg, Man.

Comme cette étude couvre beaucoup de recherches sur le développement des spores en rapport avec les rouilles sur l'avoine, il ne nous est pas possible d'en donner ici un bref résumé.

## UN MESSAGE DE SIR JOHN RUSSELL

*A mes Collègues Canadiens-Français.*

Il m'est difficile de vous exprimer le grand plaisir que j'ai éprouvé à visiter la belle province de Québec. L'invitation de M le Ministre d'agriculture, le Dr Godbout, et la bonté de mon viel ami le Dr Archibald, m'ont permis de réaliser le désir que j'avais de la voir. Avant mon voyage je savais bien des choses sur cette province: j'avais lu, comme tout le monde, le beau roman de Louis Hémon et les livres de Georges Bouchard, ces esquisses de la vie canadienne-francaise qui donnent une vision pleine d'attrait. Mais, voir les choses actuelles—les villages, les manoirs anciens, les églises aux clochers si charactéristiques et aux flèches si élégantes—et, surtout m'entretenir avec les habitants, ce fut un plaisir inexprimable. A la joie de visiter Québec s'ajoutait le plaisir d'entendre parler encore une fois la langue française—cette belle langue qui sonne si douce à nos oreilles!

L'histoire de Québec est une grande épopée! Les aventures des voyageurs, la hardiesse et le travail des habitants, leur ont gagné l'admiration vive de tout le monde. C'est une histoire de courage glorieux, de grandes souffrances et de plus grande résistance, finalement de la victoire humaine—la puissance conquérante du soc maîtrisant la forêt sauvage, et la transformant en un pays hospitalier, un paysage souriant, riche en villages et fermes et bon pour l'homme et le bétail.

Ces qualités qui ont permis un si grand accomplissement dérivent du présent et du passé. Vos devanciers ont apporté ici quelque chose de la civilisation de la France du dix-septième et du dix-huitième siècle: quelque chose que la vie dure a purifié et transformé en une vie plus simple, plus naturelle que celle des cités d'aujourd'hui. Gardez-la! Gardez les plus nobles traditions de votre race, et la fraîcheur de l'âme française, et souvenez-vous toujours des paroles de Rodolphe Lemieux: "La terre, source de nos richesses, espoir de notre avenir, non seulement fait germer la moisson, mais contribue à l'épanouissement des plus solides vertus de la race".

Non seulement faut-il conserver la meilleure partie de la vie ancienne: il faut y ajouter la meilleure partie de la vie moderne. Travaillez-donc toujours, afin que vous puissiez alléger le fardeau des souffrances et des détresses d'aujourd'hui et que vous puissiez contribuer à la richesse et à l'allégresse de la vie de demain.

E. J. RUSSELL.

*Directeur de la Station agronomique de Rothamsted,*
*Harpenden, Angleterre.*

# NOTES AND NEWS

The difficulties of maintaining a balance of interest in the contents of *Scientific Agriculture* from month to month are by no means small. This month we find our page arrangements working out in such a way that only two pages are left for news items. As we ran nine pages last month, and expect to have room for five or six in January, we hope the lapse in this issue will be overlooked.

Attention is directed to the address in this issue by Sir John Russell. It should be read in connection with the address by Sir Daniel Hall, published in the October issue. The Editor, during a recent trip to the Royal Fair, was disappointed to find that many had not read the article by Sir Daniel, and, in fact, confessed that they "had not had time" to read any of the last three issues. While we are willing to admit that in previous volumes there may have been a lack of readable material in many of the numbers, we want to remind members now that each issue of *Scientific Agriculture* contains at least one article which should be read by every member. We are making a definite effort to develop the official organ of the C.S.T.A. into a journal more representative of the Society, and as such a definite factor in the shaping of Canadian agricultural policy. This does not involve any alteration of the policy of the journal in publishing research contributions; it involves a more extensive use of economic material and the inclusion of articles on administrative policy by such outstanding authorities as we may be able to secure from time to time, and by our own members who are especially qualified to speak along this line. In this connection we would refer to the two papers on horticultural research methods in Great Britain by Mr. R. C. Palmer of Summerland in the November issue, and to a paper on animal research methods in Great Britain by Dr. R. D. Sinclair of Edmonton which will appear in January.

Following a policy adopted two years ago whereby the institution concerned pays for extra space, we have accepted an occasional long article of the type of Mr. W. L. Gordon's in this issue. This paper represents an outstanding contribution in the field of plant pathology. In cases where a research project involves a point of immediate interest in agricultural practice, we hope to follow the recommendations of previous C.S.T.A. conventions and present the material in condensed form. In this connection we have published in this issue an enlargement of the abstract of a paper published in the *Canadian Journal of Research* on the vaccination of cattle for the prevention of tuberculosis. The results obtained in this work are of vital interest to all engaged in animal husbandry, and should be of general interest to all technical agriculturists. Dr. Watson's courtesy in preparing a special statement on this subject for readers of *Scientific Agriculture* is greatly appreciated.

## ANNUAL C.S.T.A.-O.A.C. ALUMNI BANQUET

The annual joint banquet held at the time of the Royal Winter Fair under the auspices of the Central Ontario branch of the C.S.T.A. and the Ontario O.A.C. Alumni Association seems to have become a permanent institution. The committee of management is always able to count on an attendance of about one hundred and fifty members and graduates. With Paul Fisher of Burlington, President of the Alumni Association, in the chair, and Dean Howes of Edmonton, former President and one might say "Dean" of the C.S.T.A., as guest speaker, the success of the programme was assured. Some ten or twelve additional speakers failed to satisfy the demand for reminiscences, and the crowd did not disappear from the corridors for over an hour after the programme had been officially brought to a close.

Hon. T. L. Kennedy, Minister of Agriculture for Ontario, was guest of honour, and Dr. L. Ph. Roy represented Hon. Adelard Godbout, Minister of Agriculture for Quebec and President of the C.S.T.A., who was unable to be present.

## F. W. WALSH JOINS NOVA SCOTIA DEPARTMENT

Announcement has recently been made that F. Waldo Walsh, Agricultural Superintendent, Canadian National Railways, Montreal, has joined the Nova Scotia Department of Agriculture at Halifax to direct marketing activities. Mr. Walsh is a native of New Brunswick although a considerable part of his early life was spent in Nova Scotia. He graduated from the N.S.A.C. and went to Guelph where he received his B.S.A. in 1922. As a member of the O.A.C. Stock Judging Team, he was high man at the International Show at Chicago. Following graduation he was in the employ of the New Brunswick Department of Agriculture, becoming Live Stock Superintendent, and later was on the staff of the Dominion Live Stock Branch with headquarters at Truro, where he was active in promoting co-operative marketing. Subsequently he joined the staff of the N.S.A.C. as instructor in animal husbandry, resigning this position to become Maritime Agricultural Superintendent of the Canadian National Railways.

Mr. Walsh is well fitted to take up the work of promoting agricultural marketing activities in Nova Scotia. On account of his wide experience and his close personal contacts with men in all fields of agricultural services in Canada, he will undoubtedly be called upon to advise the Department along many lines. He has a background of practical farm training and is a hard worker and straight thinker. The Nova Scotia Department of Agriculture has made great progress in developing its service to the farmers in the province, and it is expected that in the field of marketing further valuable services will be rendered under the leadership of Mr. Walsh.

## ACTIVITIES OF THE MANITOBA BRANCH

The action of the Manitoba branch of the C.S.T.A. in organizing study groups for the winter months is to be highly commended. Under the leadership of the executive, headed by Mr. H. E. Wood of the Manitoba Department of Agriculture, four study groups have been organized as follows: Live Stock Problems Group, T. P. Devlin—Chairman, L. Hancock—Secretary; Agricultural Economics Group, R. D. Colquette—Chairman, George Batho—Secretary; Grain Problems Group, T. J. Harrison—Chairman, J. A. McGregor—Secretary; Dairy Problems Group, K. G. MacKay—Chairman, J. McLean—Secretary. Each of these groups has laid out a programme of papers, and an increasing amount of interest is developing. The last letter from the Secretary of the branch, Mr. J. R. Sweeney, Dominion Dairy Branch, Winnipeg, enclosed reinstatements for two members and applications for six new members, and a request for more application forms. This is the spirit which is needed at this particular time.

## NEWS ITEMS

S. W. Edgecombe (Manitoba '29) is now with the Emergency Conservation work under the United States Forest Service in the capacity of Forest Pathologist and is located at McGregor, Iowa.

D. B. Flewelling (McGill '12) is now agent for Bell and Sons of Exeter, England, handling veterinary medicines and mineral mixtures for live stock. The head office of the company is in Montreal and Mr. Flewelling is located at Bridgewater, N.S.

Hector Béliveau (Laval '26) has been appointed to the staff of the new School of Agriculture at Ste. Martine, Chateauguay County, P.Q.

M. S. Middleton, (Toronto '09) of Vernon, B.C., recently won first prize for rye at the International Show at Chicago. As Mr. Middleton was also first at the World's Grain Exhibition and Conference at Regina, he would seem to have won the undisputed title of "Rye King".

M. A. Collins (Saskatchewan '28) has moved to Toronto where he is in the employ of the Dairy Corporation of Canada, 80 King Street West.

W. S. Nesbitt (Manitoba '31) has changed his address to St. Lazare, Man.

SCIENTIFIC AGRICULTURE

Vol. XIV JANUARY, 1934 No. 5

# SOME OBSERVATIONS ON ANIMAL RESEARCH IN GREAT BRITAIN[1]

R. D. SINCLAIR[2]
*University of Alberta, Edmonton, Alberta*

In the short time at my disposal I shall attempt to convey to you some idea of the type of organization which is conducting animal research in Great Britain, and at the same time endeavour to indicate the type of problems with which they are concerning themselves.

Research work in animal husbandry in Great Britain is conducted in a number of Institutes, existing either as separate institutions or organized within established Universities. In addition certain industrial concerns interested in the manufacture of products for distribution among livestock farmers carry on research programmes with staffs of highly qualified workers.

Active research in the animal field in Great Britain is a post-war development. The majority of the existing institutions interested in animal research were established out of a $10,000,000 fund which was placed at the disposal of the Development Commission, at the close of the Great War. Out of this fund land was purchased and institutions founded and subsidized in various parts of Britain. Since the period of expansion these Institutes have had to depend largely on annual grants from Parliament, though all have certain endowment funds which help them to a considerable extent. In addition, the Empire Marketing Board has assisted in the work of the institutions by financing research projects which were expected to yield results that would have an Empire application in the field of animal husbandry. In passing it may be mentioned that the Board has also financed central bureaux or clearing houses of knowledge in special branches of research to which Home, Dominion or Colonial workers may appeal for information or for references. The bureaux which are of special interest to animal workers are the Imperial Bureau of Animal Nutrition located at the Rowatt Research Institute, Aberdeen, and the Imperial Bureau of Genetics, located at the University of Edinburgh.

The animal husbandman from Canada is likely to be impressed with the fact that there is comparatively little work of what might be called an experimental nature being done. Traditional methods have been accepted by the livestock breeder and feeder, and with quite good results it must be admitted, but the results of certain experiments conducted recently suggest that some of the traditional practices could very well be made subjects for experimental inquiry. A more extensive programme of experimental work along the lines of determining the most economical methods of feeding and general production would likely yield results which would be very enlightening. One might venture to suggest that this would be particularly true in connection with beef cattle and sheep production.

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[1] Paper delivered before the Canadian Society of Animal Production—Western Section, at the Sixth annual meeting which was held at Regina, Sask., July 31 to August 3, 1933, in connection with the World's Grain Exhibition and Conference.

[2] Associate Professor of Animal Husbandry.

The main body of investigation in the animal field is of what we commonly call the research type. The experimental routine in a feeding experiment goes beyond gross measurements of feed consumption and rate of growth and secures a result based upon some form of laboratory determination. Clinical symptoms arising out of a certain set of experimental conditions are not merely recorded but the deviation from a certain biological mean is determined and the cause of the abnormal symptom is thereby ascertained. This involves co-operation on the part of the animal husbandman with workers in the various biological sciences in his institution. Indeed some of the most fundamental results in animal science in Great Britain have been secured by men who are not essentially animal husbandmen but men trained in medicine and biology. One finds team-work a dominant note in connection with experimental programmes.

The typical animal research institute in Great Britain has departments of animal husbandry, biochemistry, physiology, pathology and bacteriology. It is felt that the animal husbandry worker can only touch one phase of a problem, and that in order to develop a project to the greatest advantage the co-operation of workers in the various biological fields is essential. A problem of definite economic significance to the livestock industry is designated by the animal husbandman, and with the collaboration of all departments a general experimental project is outlined. The various departments work on phases of the problem which come within their field. The results are published in part as special departmental papers, and when a project is completed the final conclusions are presented as a joint contribution of all concerned. Such an arrangement provides the various departments with valuable material for constructive research and leads to a result backed by more comprehensive and conclusive evidence.

The extensive use of small animals as an economical means of establishing certain nutritional or genetic principles is the common practice in animal research institutions in Great Britain. Once certain leads are secured in this way the farm animal is brought into use and the preliminary results are verified or rejected as the case may be. By the use of the small animal with a short life cycle, certain reactions can be quickly obtained and results secured in a shorter space of time and with less overhead involved than when the larger animals are used. Much inexpensive laboratory material can be secured in the form of blood and tissue when rats, rabbits and guinea pigs are the experimental subjects.

No attempt will be made to enumerate the various institutions engaged in animal research in Great Britain, nor to outline the various projects which are under consideration, but mention will be made of a few typical cases so that the type of organization and the class of problem being studied may be better appreciated.

The Rowatt. Research Institute at Aberdeen is essentially a research institution with departments of biochemistry, physiology, pathology and bacteriology, but in addition to the laboratories, an experimental farm of 1,000 acres provides beef and dairy cattle, sheep and swine for large scale feeding experiments. Pasture research has occupied a prominent place in the Rowatt programme, and mineral metabolism and the mineral requirements of farm animals have formed the basis for a comprehensive project. The influence of diet on disease is being studied by means of chemical analyses and serological tests to ascertain the influence of diet on the composition of the blood and its immunological properties. The processes of digestion and absorption in the ruminant and fowl are being studied and carbohydrate matabolism in its various aspects is a problem of major concern. In this field Dr. MacLeod of insulin fame (now at Aberdeen University) renders valuable assistance and is consulting physiologist. Feeding experiments with large groups of animals are carried out on the Duthie Experimental Farm. Comparisons are made of rates of growth and cost of production under different conditions of feeding, housing and management.

The Animal Nutrition Institute at Cambridge works in close harmony with the Rowatt Institute on problems of animal nutrition. Animal calorimetry has formed the basis for a considerable volume of effort at Cambridge and the maintenance requirements of farm animals have been carefully studied. A group of workers are engaged on a comprehensive project relating to the nutritive value of various feeding stuffs and are attacking the problem by analytical and digestibility methods. The work on the nutritive value of young grass and the development of methods for its preservation is well known. Mention should be made of the work of another division which is studying reproductive physiology including such subjects as the oestrous cycle, the causes of sterility and fertility, the vitality of spermatozoa under various conditions with a view to artificial insemination, the growth and development of farm animals, and the physiology of lactation and of meat and milk production. A poultry section deals with problems of poultry nutrition.

The Hannah Dairy Research Institute, at Anchincruive, Ayr, is a recently established institution studying problems of dairy production. Protein metabolism in relation to milk secretion is a major project, and existing feeding standards are being re-examined from the standpoint of the protein recommendations for dairy cows. Calcium metabolism in its relation to milk fever, including the effect of mineral deficiency on the calcium content of the blood at parturition and during early lactation is being studied in conjunction with the Royal (Dick) Veterinary College, Edinburgh. Accommodation is available for carrying out balance experiments with dairy cows. A specially built metabolism house will make it possible to carry out experiments for relatively long periods in which the separate collection of feces and urine will be possible.

The national Institute for Research in Dairying, University of Reading, is primarily concerned with questions relating to dairy production, but also carries on a good deal of nutritional work. Factors affecting the quality of milk are under consideration and small-animal feeding experiments are conducted to determine the nutritive value of milk mainly from the standpoint of its protein, mineral and vitamin content.

The Animal Breeding Institute, University of Edinburgh, is the main centre of study in animal genetics in Great Britain. This Institute owes its existing facilities very largely to an endowment by the International Education Board of the Rockefeller Foundation in 1927 and a further endowment in

1929 by Mr. T. B. Macauly, of the Sun Life Assurance Company of Canada. The latter endowment provided funds to buy a farm for more extensive work with farm animals. The rôle of inbreeding in the development of certain breeds of cattle is being studied and the influence of this practice on certain hereditary defects of horses is being noted. The inheritance of colour, hernia and other characters of swine is being studied and data on fertility, litter size and other aspects of the physiology of reproduction are being compiled. With sheep, colour inheritance and fertility are being studied. The influence of the thyroid on the growth of the fleece is being studied as is also the possibility of using anterior pituitary to induce oestrus at another period than that at which it normally occurs. A genetic study of the inheritance of kemp and of the possibility of eliminating it is also under way.

As was stated previously, passing mention can only be made of certain of the institutions concerned with animal research in Great Britain. There are many others carrying on investigational work and contributing to improvement in livestock production but these can only be referred to collectively. Sufficient has been said to convey some idea of the organization and type of institution functioning in that part of the British Empire and to suggest the nature of the research being conducted.

In conclusion, it would appear to the writer that the high lights of animal research in Great Britain are: (1) the organization of Institutes with departments for research in the various biological sciences; (2) team-work within the institutions in an effort to make a comprehensive study of a major project; and (3) close co-operation between institutions which are working on more or less related problems.

Great Britain with its herds, flocks, pastures and institutions of animal research offers a virgin field for exploration by the Dominion and Colonial animal husbandman. Those who have not had the opportunity of visiting this Mecca of the livestock man have a great pleasure in store.

# THE EFFECT OF FERTILIZERS ON THE YIELD AND COMPOSITION OF CROPS FROM THE WOODED SOILS OF ALBERTA[1]

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## Introduction

The podsolic wooded soils of Alberta have failed to produce satisfactory yields, especially with the grain crops, by reason of their low, natural state of fertility. Only by increasing the supply of plant nutrients in these soils will it become possible for them to produce yields which will justify their development. That satisfactory yields are possible is indicated by the experimental work with fertilizers and crop rotations which has been conducted by the Department of Soils of the University of Alberta. The material that is presented in this paper is a report of the 1932 yields obtained on the Breton Experimental Field, which is located on typical wooded soil. In addition, analytical data for the various crops is also submitted, which will show the effects of the fertilizers on the composition of the plants and the removal of plant nutrients from the soil.

## Experimental

The experimental work conducted on the Breton field includes the use of fertilizers on various legumes and grains and on a four-year rotation of wheat, oats, barley and clover. The clover crop is nursed in the barley and plowed down as a green manure crop the next year. The following fertilizer treatments, except lime and manure, are applied annually to the rotation.

| | | | |
|---|---|---|---|
| Plot | 1 | O | Check. |
| " | 2 | M | Manure, 22 tons per acre. |
| " | 3 | N P K | Complete, 100 lbs. Ammonium phosphate plus 50 lbs. KCl per acre. |
| " | 4 | N | Nitro-chalk (16% N) 120 lbs. per acre. |
| " | 5 | O | Check. |
| " | 6 | L | Lime, in the form of marl, 1100 lbs. per acre. |
| " | 7 | L P | Lime, as above, plus Triple Superphosphate at 120 lbs. per acre. |
| " | 8 | P | Triple Superphosphate, 120 lbs. per acre. |
| " | 9 | M P | Manure, 22 tons per acre plus Triple Superphosphate, 120 lbs. per acre. |
| " | 10 | N P | Ammonium phosphate, 100 lbs. per acre. |
| " | 11 | O | Check. |

Lime was applied to all rotation crops in 1931, but only on the clovers and nurse crop in 1932. Manure was applied in 1930, the next application being on the cereals in 1932. The fertilizer applications to the other crops grown will be indicated in their yield tables.

The analysis submitted is of crops from 65 different plots on the Breton field. Nitrogen was determined by official methods (*1*). Phosphorus was determined by the colorimetric method developed by Truog (*3*) using stannous chloride as a reducing agent. The samples were first moistened with 10% calcium acetate solution, dried, and ignited at 700° C. for 3 hours. They were then digested in dilute HCl, and made up to volume, aliquots being read. All samples are reported on an air dry basis, as no significant variations were found in moisture content.

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[1] This paper was constructed from a thesis submitted to the University of Alberta in partial fulfilment of the requirements for the degree of Master of Science.

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## OATS, BRETON, 1932

The oat yields in Table 1 are quite typical of the district and indicate a relatively light yield of grain, with straw yields being very low. Definite increases have been obtained by the use of fertilizers, but yields are still not satisfactory. The low yields, and the high percentage of grain in relation to straw, suggest that nitrogen may be limiting vegetative growth, and it is found that the largest and most significant increases in yield have been obtained from applications of nitrogen, and nitrogen plus phosphorus. The lime plus phosphorus application shows some increase and the rest of the fertilizers show very little. Nitrogen is apparently the most limiting factor.

TABLE 1.—*Yields and composition of oats (1932) following wheat (1931). Series A. Breton*

| Plot No. | Treatment | Yield per acre | | | Per cent composition air dry basis | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Grain | | Straw | |
| | | Grain Bus. | Straw Lbs. | Total Lbs. | N | P | N | P |
| 1 | O | 33.2 | 1255 | 2384 | 1.17 | .364 | .17 | .082 |
| 2 | M | 32.8 | 1170 | 2285 | 1.35 | .422 | .21 | .265 |
| 3 | N P K | 37.2 | 1560 | 2825 | 1.16 | .369 | .17 | .120 |
| 4 | N | 50.0 | 2135 | 3835 | 1.14 | .367 | .17 | .072 |
| 5 | O | 27.6 | 950 | 1888 | 1.32 | .438 | .20 | .233 |
| 6 | L | 33.4 | 1195 | 2331 | 1.23 | .407 | .20 | .168 |
| 7 | L P | 40.5 | 1455 | 1832 | 1.26 | .378 | .19 | .138 |
| 8 | P | 34.6 | 1320 | 2496 | 1.24 | .392 | .19 | .179 |
| 9 | M P | 36.9 | 1270 | 2525 | 1.47 | .416 | .24 | .383 |
| 10 | N P | 46.5 | 1930 | 3511 | 1.26 | .380 | .18 | .196 |
| 11 | O | 39.6 | 1510 | 2856 | 1.31 | .397 | .19 | .177 |

TABLE 2.—*Yields and composition of barley (1932) following barley* (1931). Series D. Breton*

| Plot No. | Treatment | Yield per acre | | | Per cent composition air dry basis | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Grain | | Straw | |
| | | Grain Bus. | Straw Lbs. | Total Lbs. | N | P | N | P |
| 1 | O | 15.6 | 735 | 1484 | 1.25 | .397 | .25 | .098 |
| 2 | M | 22.0 | 1130 | 2186 | 1.51 | .489 | .25 | .147 |
| 3 | N P K | 24.7 | 1740 | 2926 | 1.16 | .407 | .24 | .079 |
| 4 | N | 26.8 | 1490 | 2776 | 1.10 | .399 | .24 | .063 |
| 5 | O | 17.5 | 940 | 1780 | 1.41 | .419 | .29 | .123 |
| 6 | L | 18.3 | 975 | 1853 | 1.26 | .356 | .24 | .093 |
| 7 | L P | 21.4 | 1500 | 2527 | 1.29 | .401 | .25 | .086 |
| 8 | P | 16.5 | 790 | 1582 | 1.36 | .439 | .27 | .146 |
| 9 | M P | 27.9 | 1315 | 2654 | 1.50 | .455 | .27 | .176 |
| 10 | N P | 27.6 | 1410 | 2735 | 1.41 | .403 | .25 | .139 |
| 11 | O | 23.3 | 1145 | 2263 | 1.40 | .411 | .25 | .142 |

* Barley sown in place of oats in 1931.

*Composition of the Oat Crop.*—The percentage of nitrogen in the oat grain is low enough to seriously impair its feeding value. The content varies, with the different treatments, from 57% to 74% of the normal content (1.98%) given by Henry and Morrison (*2*). The lowest percentage of nitrogen was found in the grain from Plot 4, which received the largest amount of that element. The complete plot also gave grain low in nitrogen. Except for the applications of manure which produced grain of the highest nitrogen content, the rest of the fertilizers show little effect. The fluctuations in the percentage of nitrogen in the straw from these plots, follow very closely the variations in the grain. They are, however, even more seriously lacking in nitrogen than the grains, for a normal content is .58% (2) and they range from .17% to .24%.

Unlike nitrogen, phosphorus is found to be considerably above normal in this oat crop, especially in the straw. A normal content of phosphorus may be placed at .33% for grain and .082% for straw. Grain with the lowest content comes from the nitrogen plot and that with the highest content from the manure plots, but none of the variations are very outstanding.

### BARLEY, BRETON, 1932

This crop may be considered as an example of straight grain farming, for the rotation has not been established long enough for a green manure crop to have preceded this barley. The data in Table 2 indicate a relatively light crop of barley in spite of the increases obtained by the fertilizers. The larger increases in yield are from the plots receiving nitrogen; i.e. Plots 3, 4 and 10. The plots which received manure also show fair increases. Phosphorus or lime alone gave no increases, but they did slightly when in combination. As in the oat crop nitrogen is again the limiting factor.

*Composition of the Barley Crop.*—The fluctuations in the nitrogen content of the barley grain are much the same as in the oats. Manure applications have given the highest nitrogen contents, while the lowest percentages are in the crops receiving nitrogen alone and the complete fertilizer. The rest of the fertilizers have had, if anything, a slightly depressing effect on the nitrogen content. The percentage of nitrogen in the straw varies similarly with that of the grain. In spite of the variations present, all of the barley from this Series is below normal in protein. From the standpoint of a feed this is a disadvantage, but in the brewing industry it is desirable. The Canada Malting and Brewing Company have tested plot samples of this barley and consider them excellent for brewing purposes. The protein content of the straw is half of normal straw.

The phosphorus content of the grain is considerably over the normal of .34% and several of the plots yield straw about twice the average, .072%. The applications of phosphorus and manure, alone or in combination, show the largest increase in phosphorus content. Lime has tended to depress the phosphorus content, while the rest of the fertilizers have had little effect.

### CLOVER IN ROTATION, BRETON, 1932

On these wooded soils the response to fertilization is much greater from a legume crop than from a cereal crop. From the yields submitted in Table 3 it is evident that untreated clover crops are quite low yielding and that good yields may be obtained by fertilizers. All the plots that received phosphorus, alone or in combination, have given yields which are two and three times greater than the checks. Nitrogen and lime show substantial increases but the manure gave only a slight increase.

This clover was a mixture of alsike and white sweet clover and outstanding differences in the relative amounts of each clover were due the different treatments. On the checks and manure plots the sweet clover did very poorly, the bulk of the crop being alsike. The lime stimulated both clovers, especially the sweet clover, while the complete fertilizer favored the alsike. All the other plots had strong stands of both clovers with the sweet clover predominating.

*Composition of the Clover Crop.*—The percentages of nitrogen (Table 3) of all the clover crops, except that receiving complete fertilizer, are about normal. The complete fertilizer has increased the nitrogen content about 50%. As this plot received the same amount of nitrogen and phosphorus as Plot 10 it would appear that potassium has had a marked effect. During growth Plot 3 had a much darker color than the rest of this Series.

TABLE 3.—*Yields and composition of clover. 1932. Series C. Breton.*

| Plot No. | Treatment | Yield per acre (lbs.) | Per cent composition air dry basis | | |
|---|---|---|---|---|---|
| | | | N | P | Ca |
| 1 | O | 1225 | 2 02 | .316 | 1 55 |
| 2 | M | 1665 | 2 07 | 285 | 1 43 |
| 3 | N P K | 4395 | 3 02 | 283 | 1 14 |
| 4 | N | 3160 | 2 16 | 237 | 1.43 |
| 5 | O | 1390 | 2 14 | .280 | 1 48 |
| 6 | L | 3835 | 2 01 | 244 | 1.42 |
| 7 | L P | 4515 | 2 31 | 304 | 1 43 |
| 8 | P | 4230 | 2 18 | 314 | 1 20 |
| 9 | M P | 4510 | 2 21 | 328 | 1 42 |
| 10 | N P | 4220 | 2 26 | 314 | 1 34 |
| 11 | O | 2490 | 1 99 | 301 | 1 50 |

A normal phosphorus content for these clovers ranges between .25% and .28%. Thus all the plots, except those receiving only nitrogen and lime, are normal or slightly above normal in the amount of phosphorus they contain. Nitrogen and lime have slightly depressed that element.

The calcium contents of the clovers, as a whole, are close to normal. The crops from the complete and phosphorus plots are a little on the low side while the checks are the highest. The addition of lime has had no distinct effect on the calcium content of the crop.

## WHEAT, BRETON, 1932

The benefits of rotation coupled with the combined use of green manures and fertilizers are well demonstrated in the yields which have been obtained on Series B (see Table 4). This crop immediately follows a green manure crop, and during all its growing season was outstandingly heavier and healthier than any other grain crop on the field. Yields have been increased from 11.4 bushels per acre, which is an ordinary wheat yield for the district, to the very satisfactory yield of 45.9 bushels.

TABLE 4.—*Yields and composition of wheat (1932) following clovers turned under (1931). Series B. Breton.*

| Plot No. | Treatment | Lbs. of Green manure per acre | Yield per acre | | | Per cent composition air dry basis | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Grain Bus. | Straw Lbs. | Total Lbs. | Grain | | Straw | |
| | | | | | | N | P | N | P |
| 1 | O | 2197 | 21 4 | 1850 | 3134 | 2 68 | .455 | .57 | .273 |
| 2 | M | 2208 | 28.3 | 2780 | 4478 | 2.13 | .480 | .27 | .096 |
| 3 | N P K | 3822 | 43 1 | 4280 | 6866 | 2 16 | .391 | .30 | .034 |
| 4 | N | 5140 | 22 6 | 2020 | 3376 | 2 80 | .518 | .53 | .169 |
| 5 | O | 1278 | 17 0 | 1130 | 2150 | 2 69 | .480 | .52 | .204 |
| 6 | L | 3574 | 26 3 | 2195 | 3773 | 2 35 | .490 | .38 | .154 |
| 7 | L P | 4087 | 36 6 | 3325 | 5521 | 2 25 | .435 | .27 | .081 |
| 8 | P | 4055 | 30.2 | 2930 | 4742 | 2 31 | .461 | .29 | .082 |
| 9 | M P | 4047 | 45.9 | 4250 | 7004 | 2.33 | .460 | .29 | .110 |
| 10 | N P | 3734 | 34.7 | 3165 | 5247 | 2 65 | .521 | .35 | .121 |
| 11 | O | 2291 | 19 8 | 1590 | 2778 | 2.87 | .490 | .61 | .275 |
| *Wheat (1932) following clovers all removed (1931). Series F, Breton.* | | | | | | | | | |
| 1 | O | None | 11 4 | 920 | 1604 | 2 71 | .505 | ... | .... |
| 3 | N P K | Plowed | 25 6 | 2315 | 3851 | 2.12 | .460 | ... | .... |
| 4 | N | Down | 15.6 | 1340 | 2276 | 2.81 | .494 | ... | .... |

These large increases are due to the combined effects of clover and fertilizers. The increase that was obtained by just the use of clover and no fertilizer is indicated by the 10 bushel increase on Plot 1B over Plot 1F. Series F had no clover plowed down for the clover crop was allowed to ripen and then removed. The fertilizers had a double opportunity of increasing yields, for besides supplying plant food, they also increased the amounts of green manure the previous year. It will be noted that all the plots that received phosphorus are among the high yielders, the manure plus phosphorus and the complete fertilizer yielding the highest. A fair response was obtained from the use of lime or manure alone, but nitrogen even with the large amount of clover plowed down did not significantly increase the yield.

*Composition of the Wheat Crop.*—The analysis of the wheat shows no lack of nitrogen as was the case in the oats and barley. On both Series B and F, the grain from the checks, the ammonium phosphate plot and the plots receiving nitrogen alone, are slightly above normal in protein, while the complete fertilizer and the manure plot show a slight depression. The rest of the crops are about normal. The straw, however, of the higher yielding plots is about 50% below the normal content of .5%, the checks being about average. The phosphorus content of all the grains, except from the complete are somewhat above the average of .49%, some are as much as 25% higher. There is a large degree of fluctuation in the percentage of phosphorus in the straw. An average content of .08% indicates several crops with over twice this amount. The percentage of phosphorus in the straw shows a strong relationship to the stage of maturity, due likely to translocation.

## OTHER LEGUMES, BRETON, 1932

Series F and H, were summer-fallowed the year before they were sown to legumes, and indicate that very good initial crops may be obtained by this practice, even without the use of fertilizers. Yields of approximately 2 tons per acre for untreated alfalfa and alsike are considered very good. The effects of the fertilizers in increasing yields in these cases are not as outstanding but they generally give small increases. Older stands of legumes, such as the red clover, yield much lower on their check plots, and their yields are more than doubled by fertilization. The mixture of western rye and alsike, also an old stand, shows very low check yields with fertilized plots yielding from 2 to 5 times greater crops.

TABLE 5.—*Other legumes, Breton, 1932.*

| Crop | Treatment, lbs. per acre | Yield lbs. per acre | Per cent composition | |
|---|---|---|---|---|
| | | | N | P |
| Alfalfa Series H | Check | 3980 | 2.39 | .184 |
| | Marl 1200 | 3445 | 2 34 | .207 |
| | Marl 1200 + Amm. Phos. 100 | 4400 | 2 39 | .228 |
| | Amm. Phos. 100 | 3755 | 2 43 | .240 |
| Sweet Clover Series H | Check | 2252 | 2 48 | .275 |
| | Marl 1200 | 2855 | 2 26 | .260 |
| | Marl 1200 + Amm. Phos. 100 | 3525 | 2 77 | 296 |
| | Amm. Phos. 100 | 3880 | 2 67 | 286 |
| Alsike Clover Series H | Check | 4330 | 2 09 | 285 |
| | Marl 1200 | 4660 | 2.11 | .236 |
| | Marl. 1200 + Amm. Phos. 100 | 4860 | 1 91 | 283 |
| | Amm. Phos. 100 | 5265 | 2 35 | .318 |
| Alsike Clover Series F | Check | 3850 | 1 93 | .269 |
| | Triple Superphos. 120 | 4230 | 2.26 | 296 |
| | Amm. Phos. 100 | 4860 | 1.88 | .326 |
| Red Clover Series G | Check | 1330 | 1 77 | .255 |
| | Triple Superphos. 120 | 3485 | 1.81 | 246 |
| | Amm. Phos. 100 | 2560 | 1 77 | .... |
| Alsike & Western Rye Hay Mixture | Check 5 | 803 | 2 11 | .406 |
| | Check 11 | 935 | 2.29 | .477 |
| | Amm. Phos. 100 | 1740 | 1.94 | .361 |
| | Triple Superphos. 120 | 1975 | 1 94 | .309 |
| | Nitro-chalk 120 | 2835 | 1 97 | .281 |
| | Complete 150 | 4520 | 1.64 | .254 |

*Composition of the Legumes.*—Considering the legumes of Series F and H, the application of ammonium phosphate has tended to increase slightly the percentage of phosphorus in the crop, and sometimes to increase slightly the nitrogen. The marl has had no distinct effect on composition. As a whole these legumes are above normal in phosphorus, and close to an average nitrogen content. The effects of the fertilizers on the mixture of alsike and western rye are very outstanding. All the fertilizers causing large increases in yield have greatly depressed the phosphorus and nitrogen content. The phosphorus content of these check crops is almost twice normal. The nitrogen content is fairly good in the checks of this hay mixture, but has been considerably lowered on the higher yielding plots.

## DISCUSSION

It has been indicated that cereal crops grown on podsolic wooded soils are primarily limited by lack of nitrogen and that following a green manure crop yields increase substantially with greater response being obtained from fertilizers. Table 6 shows the relative amounts of nitrogen and phosphorus utilized by the different crops and supplied by the different fertilizers. It will immediately be noted that the clover of 1931 on Series B supplied amounts of nitrogen which, except on Plot 5, were larger than the amounts removed by the following wheat crop, and are several times larger than the amounts supplied by the fertilizers. When no fertilizers were used, one ton of green manure (dry wt.) supplies sufficient nitrogen (not considering any losses) for the wheat crop the next year, and (by Plot 4) no further significant increase is obtained by more nitrogen. With the application of phosphorus (Plot 10) even with less nitrogen than on Plot 4, the yield increases from 22.6 to 34.7 bushels. By the addition of potassium on Plot 3, where there is apparently still less nitrogen but approximately the same amount of phosphorus, the yield reaches 43.1 bushels. This would appear to indicate that in order of scarcity, nitrogen, phosphorus and potassium are all necessary on these soils if satisfactory yields are to be obtained. Further evidence that phosphorus is not primarily limiting is shown by the very high ratio of phosphorus to nitrogen in the oats and barley; a ratio of 1:5 being close to normal. It will also be noted there has been very low utilization of the phosphorus applied to the cereals, but a fairly good utilization when applied to the legumes. An untreated clover crop uses slightly less phosphorus than an untreated grain crop, but the wheat crop following the green manure uses almost twice the amount. This method of green manuring without phosphorus would hasten depletion of that element in the soil.

Regarding the effect of fertilizers on composition it may be said that the fertilizers giving the larger increases, such as those from nitrogen on the barley

TABLE 6.—*Removal of nitrogen and phosphorus (lbs.) per acre by different crops.*

| Plot No | Treatment | Series A Oats (1932) | | Series D Barley (1932) | | Series C Clover (1932) | | Series B Wheat (1932) | | Series B Clover (1931) | Supplied by fertilizers | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | N | P | N | P | N | P | N | P | N | N | P |
| 1 | O | 15 3 | 5 1 | 11 2 | 3 7 | 24 7 | 3.9 | 45.0 | 10 9 | 46 5 | | |
| 2 | M | 17 5 | 7 8 | 18 8 | 6 8 | 34.5 | 4 7 | 43.7 | 10.8 | 64.0 | | |
| 3 | N P K | 17 3 | 6 6 | 17 9 | 6.2 | 132 7 | 12 3 | 68 7 | 11.6 | 76 8 | 10 | 20 |
| 4 | N | 23.0 | 7.7 | 17 7 | 6 1 | 68.3 | 7.5 | 48.7 | 10.4 | 111 5 | 20 | |
| 5 | O | 14 3 | 6 3 | 14.6 | 4.7 | 29.7 | 3.9 | 33.3 | 7.2 | 23.1 | | |
| 6 | L | 16 4 | 6 6 | 13.4 | 4 0 | 77.1 | 9 4 | 45.4 | 11.1 | 64.0 | | |
| 7 | L P | 20.1 | 7.2 | 17.0 | 5.4 | 104 3 | 13.7 | 58.4 | 12 2 | 94 8 | | 25 |
| 8 | P | 17.1 | 7.0 | 12 9 | 4.6 | 92 2 | 13.3 | 50.4 | 10.8 | 91 2 | | 25 |
| 9 | M P | 21.5 | 10.1 | 23 6 | 8.4 | 99 7 | 14 8 | 76.5 | 17.4 | 91 9 | | 25 |
| 10 | N P | 23.4 | 9.8 | 22.2 | 7.3 | 95 4 | 13.3 | 66 3 | 14.7 | 89.2 | 10 | 20 |
| 11 | O | 20.5 | 8.1 | 18.5 | 6.2 | 49 6 | 7.5 | 43.8 | 10.2 | 47.7 | | |
| Ave. Removal | | 18 7 | 7.5 | 17.1 | 5.8 | 73.5 | 9.5 | 52.7 | 11.5 | 72.8 | | |
| Ratio of N to P | | 2.5:1 | | 2.9:1 | | 7.7:1 | | 4.6:1 | | | | |

and oats, phosphorus on the red clover or any of the fertilizers on the alsike and western rye mixture, are accompanied by a lowering of their content in the crop. On the other hand where increases were not large, as experienced by the phosphorus applied to the legumes of Series H or to the barley, the element tended to accumulate in the plant. As a general rule the content of nitrogen and phosphorus in the cereals was closely and inversely related to yield, and any increase in the total produce of one plot over another lowered the nitrogen and phosphorus content. With the legumes the nitrogen percentage generally increased with the yield, due probably to greater fixation.

## Summary

1. The yields and composition of various crops grown on the podsolic wooded soils of Alberta with various fertilizers are reported.
2. The use of green manure legume crops with fertilizers gave increases in wheat yields up to four times that of the checks.
3. Generally where relatively large increases in yield were obtained by fertilizers, the nitrogen and phosphorus contents were reduced, an exception being the nitrogen content of clover which often increased with yield.
4. Oat and barley crops were seriously below normal in protein content whether fertilized or not.

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# CURRENT PUBLICATIONS

Report of the Royal Commission on Banking and Currency in Canada, 1933. J. O. Patenaude, King's Printer, Ottawa. Price, 50 cents.

The whole problem with which the Commission had to deal may be summarized as follows: What is the general economic position of Canada? Are the existing banking and financial mechanisms adequately equipped to cope with the monetary and financial problems to which such situation gives rise?

After a complete survey of the situation, the Commission by a majority recommended that a central bank for Canada be forthwith established, and unanimously recommended that an inquiry be instituted by the Dominion Government, preferably with the co-operation of the Provincial Governments, to investigate the existing organizations for the provision of rural credit with a view to the preparation of a scheme for the consideration of Parliament.

In the last paragraph of the chapter dealing with rural credit, the Commission stated that the material available on this subject during the course of the inquiry was not sufficient to enable it to make a specific recommendation as to the precise form which such an organization might take. Evidence presented satisfied the Commission that the need for such an agency is a real one. Agriculturists will receive with special interest the recommendation regarding the organization of an adequate rural credit system in Canada.

# BUNT INFECTION OF SPRING WHEAT BY SOIL-BORNE SPORES[1]

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[Received for publication October 25, 1932]

In a recent paper (*1*) the writers reported that spores of the bunt-fungus, *Tilletia tritici* (Bjerk.) Wint., which had overwintered in infected wheat-heads lying on the surface of the ground were capable of varying degrees of germination the following spring, whereas those which had overwintered in buried heads were less viable.

This experiment was repeated in the winter of 1932-33. Heads of Mindum wheat infected with *T. tritici* were sent in October, 1932, to the following places: Morden, Man., Brandon, Man., Indian Head, Sask., Saskatoon, Sask., and Edmonton, Alta. Some of these heads were placed to overwinter on the surface of stubble-land, and others were buried about six inches below the surface. Bunted heads of Mindum wheat were allowed to overwinter in the same way at Winnipeg. In the spring of 1933, when wheat seeding had begun, the bunted heads were collected and sent to the laboratory at Winnipeg for tests of spore-germination. The results of the germination tests are summarized in Table 1.

TABLE 1.—GERMINATION TESTS OF BUNT-SPORES OVERWINTERING IN INFECTED WHEAT-HEADS IN WESTERN CANADA. (1932-33).

| Station | Germination | |
|---|---|---|
| | Heads placed on surface of ground | Heads buried 6 inches |
| Winnipeg | low | low |
| Brandon | medium | " |
| Morden | " | " |
| Indian Head | " | " |
| Saskatoon | high | " |
| Edmonton | " | medium |

As in the 1931-32 experiment, the spores which had overwintered in heads placed on the surface of the ground were capable of varying degrees of germination. Those from Saskatoon and Edmonton germinated as abundantly as spores from heads which had been stored in the laboratory at Winnipeg. With the exception of the Winnipeg collection, the spores which had overwintered in buried heads were less viable than those which had overwintered on the surface of the ground.

An experiment was made also to determine the capacity for infection of overwintering bunt-spores. On October 13, 1932, spores of *T. tritici* which had been sifted through a 200-mesh sieve were scattered over the surface of a plot four feet square situated near the laboratory. Two other plots of the same size were inoculated in the same manner, one with bunt-balls of *T. tritici*, and the other with bunted heads infected with this species. The inoculum on each of the three plots was then well mixed with the surface layer of soil.

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[1] Contribution from the Division of Botany, Experimental Farms Branch, Department of Agriculture, Ottawa.

Cooperative experiment made by the Dominion Rust Research Laboratory, Winnipeg, the Dominion Laboratories of Plant Pathology at Saskatoon and Edmonton, and the Dominion Experimental Farms at Morden, Brandon, and Indian Head.

[2] Senior Plant Pathologist, and Assistant Plant Pathologist respectively.

During the winter the plots became buried in snow. Early in the spring of 1932, after the snow had melted, they were covered with water for several days. Records of the soil-temperatures prevailing throughout the winter were not kept. At the Manitoba Agricultural College, however, the lowest air-temperature recorded during the winter of 1932-33 was -42° F.

On April 25, 1933, formalin-treated seed of Ceres wheat, a susceptible variety, was sown on each of the plots. A fourth plot nearby, which had not received any inoculum, was likewise sown with Ceres wheat as a control.

When the wheat growing on the four plots had ripened, it was examined for bunt-infection, and counts were made of the number of infected heads in each plot.

Eleven bunted heads were found in the plot which had received sifted bunt-spores; 29 in the plot which had received bunt-balls; and 45 in the plot which had received bunted heads. No infected heads were found in the control plot. Some of the infected heads found in the two plots which had received either bunt-balls or bunted heads were borne on volunteer plants of Mindum and Reward. These plants grew from sound kernels in partially bunted heads of the varieties which had been used as inoculum.

It is apparent that under the conditions of these experiments some of the bunt-spores overwintered successfully and were capable of causing infection the following spring. Judging by the relative amounts of infection in the three inoculated plots, spores which overwinter in bunted heads are more likely to retain their viability than those which overwinter in direct contact with the soil.

The degree of infection in all of the plots was relatively light when considered in relation to the quantity of inoculum applied to them. Hence, it is probable that only a small proportion of the spores retained their viability until the spring. This conclusion is supported by the results of the germination tests with spores overwintering in the field at Winnipeg, as given in Table 1.

## SUMMARY

1. The results of germination tests of bunt-spores (*Tilletia tritici*) which had overwintered in the field in 1932-33 were similar to those of the preceding year. Spores from infected heads of Mindum wheat overwintering on the surface of the ground germinated better than those from buried heads.

2. In the fall of 1932, bunted heads, bunt-balls, and sifted bunt-spores were applied to each of three plots. Formalin-treated Ceres wheat sown on these plots in the spring of 1933 produced a number of bunted plants. Some of the volunteer plants growing on the plots which received bunted heads and bunt-balls were also infected.

## REFERENCES

1. Hanna, W. F. and W. Popp. The overwintering of bunt spores in Western Canada. Sci. Agr. *13*: 636-637. 1933.

# THE ECONOMIC ANNALIST

A REVIEW OF AGRICULTURAL BUSINESS PREPARED QUARTERLY BY THE AGRICULTURAL ECONOMICS BRANCH, DEPARTMENT OF AGRICULTURE, OTTAWA

Vol. III. Nos. 10, 11, 12. Oct., Nov., Dec., 1933

## THE ECONOMIC SITUATION

PREPARED IN THE AGRICULTURAL ECONOMICS BRANCH, DEPARTMENT OF AGRICULTURE, OTTAWA, FROM BASIC DATA COLLECTED BY THE DOMINION BUREAU OF STATISTICS

An upturn was registered in wholesale prices in Canada during November. The index number computed by the Dominion Bureau of Statistics was, therefore, 68.7 as compared with 67.9 in October. Gains were recorded in the vegetable products group, animals and their products, wood, wood products and paper, iron and its products, and non-ferrous metals and their products. Fibres, textiles and textile products, non-metallic minerals and their products, and chemicals and allied products declined.

*Retail Prices.* The index of retail prices, rents and costs of services rose from 77.9 in October to 78.1 in November. The advance was largely due to increased prices in the food group and, to a lesser degree, to an advance in the fuel index.

*Employment.* The index of employment advanced from 88.4 at the first of November to 90.9 at the first of December. This is 8 points above the index as at December 1st, 1932.

*Physical Volume of Business.* The index number of physical volume of business receded to 85.5 in November. Industrial production dropped from 87.4 to 83.9. The index of manufacturing eased downward from 87.9 to 86.2. The forestry index on the other hand advanced from 86.2 to 87.2. Iron and steel production fell from 37.3 to 33.4. The construction index declined from 42.6 to 37.3. Electric power production advanced from 148.8 to 158.1. Imports were higher but the export index declined.

*Agricultural Products.* Prices of Canadian farm products advanced in November. The index of field products rose from 44.6 to 46.7. The index of animal products rose from 62.8 to 65.8. The total index thus moved up from 51.4 in October to 53.8 in November. The average closing price of No. 1 Manitoba Northern wheat at Fort William was 60.5 cents per bushel in October as compared with 63.7 cents in November. Prices of barley, oats, flax and rye were somewhat higher. Better prices were obtained for cattle, hogs, sheep, lambs, milk, eggs and wool, and caused the index of animals and animal products to rise three points. While prices of farm products are still very low, it will be observed that on the whole the trend has been upward in 1933.

Agricultural marketings were much below those in October. The index of grain marketings dropped from 70.0 to 36.7, the wheat index fell from 75.6 to 40.1, oats from 97.2 to 35.9. Relatively little barley, flax or rye moved. The total index thus fell from 70.5 in October to 41.8 in November.

Livestock marketings held up better than those of grain. The index of cattle marketings declined from 56.2 to 50.7. Hogs dropped from 93.6 to 88.0. Sheep marketings declined from 98.8 to 61.7. There was quite a reduction in the movement of calves, the index falling from 102.8 in October to 89.9 in November. The total index, therefore, dropped to 41.8.

The index of cold storage holdings was slightly lower in November. Stocks of eggs, lard, and cheese were higher than in October but those of other commodities were lower than in the previous month. The most notable change was reported in mutton supplies.

## ANNUAL AND MONTHLY INDEX NUMBERS OF PRICES AND PRODUCTION COMPUTED BY DOMINION BUREAU OF STATISTICS

| Year | Wholesale Prices 1926 = 100 | | | | Retail prices and cost of services (5) | Production (6) 1926 = 100 | | | |
|---|---|---|---|---|---|---|---|---|---|
| | All commodities (1) | Farm products (2) | Field products (3) | Animal products (4) | | Physical volume of business | Industrial production | Agricultural marketings | Cold Storage holdings |
| 1913.... | 64.0 | 62.6 | 56.4 | 77.0 | 65.4 | .... | .... | .... | .... |
| 1914.... | 65.5 | 69.2 | 64.9 | 79.0 | 66.0 | .... | .... | .... | .... |
| 1915.... | 70.4 | 77.7 | 76.9 | 79.2 | 67.3 | .... | .... | .... | .... |
| 1916.... | 84.3 | 89.7 | 88.4 | 92.3 | 72.5 | .... | .... | .... | .... |
| 1917.... | 114.3 | 130.0 | 134.3 | 119.6 | 85.6 | .... | .... | .... | .... |
| 1918.... | 127.4 | 132.9 | 132.0 | 134.7 | 97.4 | .... | .... | .... | .... |
| 1919.... | 134.0 | 145.5 | 142.4 | 152.5 | 107.2 | 71.3 | 65.5 | 48.1 | 47.1 |
| 1920.... | 155.9 | 161.6 | 166.5 | 149.9 | 124.2 | 75.0 | 69.9 | 52.6 | 94.2 |
| 1921.... | 110.0 | 102.8 | 100.3 | 108.5 | 109.2 | 66.5 | 60.4 | 65.2 | 86.4 |
| 1922.... | 97.3 | 86.7 | 81.3 | 99.1 | 100.0 | 79.1 | 76.9 | 82.6 | 82.6 |
| 1923.... | 98.0 | 79.8 | 73.3 | 95.1 | 100.0 | 85.5 | 83.8 | 91.4 | 87.8 |
| 1924.... | 99.4 | 87.0 | 82.6 | 97.2 | 98.0 | 84.6 | 82.4 | 102.5 | 114.6 |
| 1925.... | 102.6 | 100.4 | 98.1 | 105.7 | 99.3 | 90.9 | 89.7 | 97.2 | 108.9 |
| 1926.... | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| 1927.... | 97.7 | 102.1 | 99.9 | 105.7 | 98.4 | 106.1 | 105.6 | 103.6 | 110.0 |
| 1928.... | 96.4 | 100.7 | 92.6 | 114.3 | 98.9 | 117.3 | 117.8 | 146.7 | 112.8 |
| 1929.... | 95.6 | 100.8 | 93.8 | 112.5 | 99.9 | 125.5 | 127.4 | 101.1 | 109.6 |
| 1930.... | 86.6 | 82.3 | 70.0 | 102.9 | 99.2 | 109.5 | 108.0 | 103.0 | 128.4 |
| 1931.... | 72.2 | 56.3 | 43.6 | 77.6 | 89.6 | 93.5 | 90.4 | 99.0 | 125.7 |
| 1932.... | 66.7 | 48.4 | 41.1 | 60.7 | 81.4 | 78.7 | 74.0 | 114.3 | 120.1 |
| 1933 | | | | | | | | | |
| Jan..... | 63.9 | 43.6 | 35.1 | 57.9 | 79.1 | 68.1 | 62.2 | 56.1 | 112.0 |
| Feb..... | 63.6 | 43.0 | 36.0 | 54.7 | 78.4 | 67.0 | 60.9 | 76.5 | 127.6 |
| Mar..... | 64.4 | 44.7 | 38.0 | 56.0 | 77.8 | 68.4 | 62.5 | 129.0 | 135.8 |
| April... | 65.4 | 46.8 | 41.1 | 56.4 | 78.1 | 69.8 | 65.1 | 104.1 | 112.7 |
| May.... | 66.9 | 51.2 | 46.9 | 58.4 | 77.0 | 76.4 | 72.7 | 95.4 | 100.4 |
| June.... | 67.6 | 52.6 | 49.4 | 57.9 | 77.0 | 82.2 | 79.8 | 221.9 | 119.9 |
| July... | 70.5 | 60.1 | 60.8 | 59.0 | 77.2 | 84.1 | 82.6 | 136.3 | 114.5 |
| Aug..... | 69.4 | 57.0 | 54.9 | 60.5 | 78.6 | 89.8 | 89.5 | 197.2 | 114.2 |
| Sept.... | 68.9 | 54.7 | 49.5 | 63.4 | 78.8 | 90.8 | 90.2 | 101.1 | 115.7 |
| Oct..... | 67.9 | 51.4 | 44.6 | 62.8 | 77.9 | 88.2 | 87.4 | 70.5 | 112.7 |
| Nov.... | 68.7 | 53.8 | 46.7 | 65.8 | 78.1 | 85.5 | 83.9 | 41.8 | 111.1 |

1. See Prices and Price Indexes 1913-1928, pp. 19-21, 270-289 and 1913-1931, p. 15

2. Wholesale prices of Canadian products of farm origin only. See Prices and Price Indexes 1913-1931, p. 33, and Monthly Mimeographs 1932 and 1933.

3. Wholesale prices of grains, fruits and vegetables.

4. Wholesale prices of Animals and Animal Products.

5. Including foods, rents, fuel, clothing and sundries, See Prices and Price Indexes 1913-1928, pp. 181-185, 290-293. 1926 = 100.

Prices and Price Indexes 1913-1931, pp. 122, and Monthly Mimeographs 1932-1933.

6. Monthly Review of Business Statistics, pp 8, and Monthly Indexes of the Physical volume of business in Canada, supplement to the Monthly Review of Business Statistics, November, 1932.

*Field Crops.* The Agricultural Branch of the Dominion Bureau of Statistics recently released its annual statement of the area sown to field crops. It is interesting to note that there was a reduction of over a million acres in the total. The area sown in 1932 was 57,734,000 acres while in 1933, 56,580,550 acres were planted. Total wheat acreage was reduced from 27,182,000 acres to 25,991,100 acres. The acreage in oats increased from 13,148,400 acres in 1932 to 13,528,900 in 1933. Barley on the other hand occupied 3,757,600 acres in 1932 and 3,658,000 acres this year. There was a considerable reduction in the acreage of rye, the figure for 1932 was 773,800 while 583,100 acres were sown in 1933. Acreage in flax was also lower in 1933 when 243,600 acres were sown as against 453,700 acres in 1932. There has been a substantial increase in the acreage of alfalfa. Changes in acreage of other crops are not large.

Yields per acre of crops given above were as follows: wheat 15.8 bushels in 1932 as against 10.5 in 1933, oats 29.8 and 23 bushels for the respective years, barley 21.5 and 17.4, rye 11.6 and 8.1, flax seed 5.4 and 2.8, mixed grains 33.0 and 28.4 bushels per acre.

The value of field crops was estimated to be $432,199,400 in 1931, as against $444,894,900 in 1932, and $427,791,000 in 1933. The average estimated values were as follows: wheat 35 cents per bushel in 1932 and 45 cents in 1933; oats 19 cents and 25 cents respectively; barley 23 and 26; rye 27 and 34; flax seed 62 and $1.12; and mixed grains 33 cents and 39 cents. These figures are of course preliminary.

*Numbers of Live Stock.* The Bureau reports that the number of horses on farms declined in 1933. Cattle numbers increased. Sheep and swine are fewer this year than last. There has been a drastic reduction in the number of hens and chickens but other kinds of poultry have increased.

*Live Stock Marketings.* According to the Live Stock Market Report, December 21st, cattle marketed during 51 weeks of 1933 numbered 590,467 as compared with 563,636 during the same period of 1932. Calf marketings in the same periods were 312,522 and 298,269 respectively. Marketings of sheep were 464,058 in 1933 and 463,010 in 1932. Hogs marketed at public yards and direct to packing plants numbered 3,087,582 this year as compared with 3,056,119 during 1932.

*Butter Production.* For the ten months ending October 31st, butter production in Canada is reported by the Federal Dairy Branch to have been 195,237,239 pounds as compared with 190,018,592 pounds in the same period of 1932, an increase of 2.7%. Production decreased in Prince Edward Island, New Brunswick, Quebec and British Columbia but increased in the other provinces. Alberta had the highest increase amounting to 13.3% over 1932 and Saskatchewan had the second largest increase, 10.4%.

*Cheese Gradings.* Boxes of cheese graded during the period November 28, 1932 to December 2nd, 1933 numbered 1,171,034 as against 1,296,444 boxes in approximately the previous twelve month period.

*Apples and Potatoes.* Commercial apple production as estimated by the Fruit Branch has been placed at 4,892,000 bbls. in 1933 as against 3,977,000 in 1932. The potato crop was placed at 527,700 acres in 1933 as against 521,500 acres in 1932. The yield was estimated to be 41,542,000 cwts. this year as compared with 39,416,000 cwts. in 1932.

## AUSTRALIA PLANS NEW MARKETING METHODS TO COMPLY WITH WORLD WHEAT AGREEMENT

According to a recent article in "Foreign Crops and Markets" no legislation will be necessary in Australia to ensure compliance with the International Wheat Agreement. A proclamation will be issued prohibiting export of grain or flour except under permit. All exporters will require licences, and will be allotted definite export quotas based on previous volumes handled. Licences to export will be subject to conditions. "Each licenced exporter will be required to undertake to buy from farmers, as long as they are freely offering wheat for sale, or to hold for farmers and make advances in respect thereof, one bushel of wheat for every two bushels which he is entitled to export during the year from August 1, 1933, to July 31, 1934". Exporters who purchase more than they can export during this period will be permitted to export freely the following year but such carryover amounts will be taken into consideration in determining the individual export quotas for 1934-35. If merchants do not offer world parity for the whole of the exportable surplus of wheat the Commonwealth itself will purchase the wheat.

# EFFORTS TO CONTROL MARKETING BY GOVERNMENT BOARDS OR ORGANIZATIONS ACTING WITH GOVERNMENT SUPPORT

## PART II[1]

J. COKE[2]

In this article discussion of controlled marketing is continued. It is not the purpose of the author to discuss the relative merits of these schemes or to compare potential results with those secured under the usual method of marketing. It is rather to present available information on marketing plans adopted in various countries and on which readers may not readily be able to secure data.

*The Bulgarian Cereal Monopoly.*—The exercise of public monopoly control has become prevalent in some countries and particularly with respect to bread grains and tobacco.

In December, 1930 the Bulgarian Government established the Central Grain Purchasing Bureau. This Bureau was given power to purchase wheat and rye at fixed prices and began its operations in February, 1931. It used co-operative associations, banks and merchants as its agents and made payments to producers in cash and in taxation credits; the latter were redeemable prior to September 1st, 1931. It was thus a means of enabling the farmer to pay his taxes but it reduced the State income by an equivalent amount and at the same time added to the burdens of the Treasury[3]. At the outset payments for wheat were to be only twenty-five per cent in cash but fifty per cent in cash might be paid in the case of purchases of rye. The cash ratio was revised upward in August, 1931. The Bureau was given power to fix storage rates where it found it necessary to do so.

Funds were provided for its use through loans from the Agricultural Banks as well as the Co-operative Bank. Altogether its original loans amounted to $288,000. When the Bureau was established it was merely authorized to purchase wheat and rye at prices higher than those obtainable in world markets. Such prices were to be decided in conference with representatives of the Government, the banks, the co-operatives and the grain exchanges[4].

The Bureau paid prices above world parity, and consequently the amount of grain handled in the early months of operation was larger than anticipated and the prices paid were reduced. Nevertheless, after about eight months' operation it was found that the cash payments for grain exceeded the amount of sales and it was then decided that the Government should assume exclusive control. Accordingly, in October, 1931, a series of orders-in-council proclaimed this intention. The Central Grain Purchasing Bureau continued to administer the regulations. The Bureau thus became the sole buyer or seller of cereals in the country and it was also proclaimed to be unlawful for flour to be sold unless it had been made from wheat purchased from, or controlled by the Bureau. The milling industry was brought under the direct supervision of the Bureau. A controller was appointed for each large commercial mill and in cases where several small mills could be conveniently grouped these were placed under the direction of a single controller. It is the duty of the controller to audit the books and check all declarations. The salaries of these officers are collected by the Bureau out of funds contributed by the commercial mills. The custom mills were placed under the direction of the mayor of the municipality in which they are located, and it is necessary to secure a permit from him in order to grind wheat and rye.

In connection with sales, provision was made for compulsory registration of all export sales on the stock exchange located at the point of delivery for export. A brokerage charge of 2% is to be paid to the exchange. Similarly, all sales for local consumption are to be registered on the Sofia Exchange and the brokerage charge in this case is 1%, which amount is redistributed among the exchanges on a proportionate basis.

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[1] See The Economic Analist, Vol. III, Nos. 7, 8 and 9, pp. 76-78; and Scientific Agriculture *14*: 76-78.

[2] Assistant Commissioner, Economics Branch, Department of Agriculture, Ottawa.

[3] Dolinsky, N. V. The agricultural situation in Bulgaria. Report to the International Conference of Agricultural Economists, 1933. Mimeographed, pp. 9-10.

[4] For a more complete statement see Edminster, L. R., Schaben, L. J., and Lynsky, M., F-S 56. Agricultural price supporting measures in foreign countries. Bureau of Agricultural Economics, U.S. Department of Agriculture, Washington, D.C., p. 44.

Early in 1932 a special cartel or monopoly law was enacted which empowered the State to dissolve monoplies and to fix prices. Action has already been taken with respect to the sugar monopoly. Prices of flour, sugar, copper sulphite, sunflower seed oil and other products have been officially set .

Other countries have acquired monopoly control over certain cereals or other products; for example, Poland, France, Greece, Japan and Hungary. Germany has a quasi monopoly to control wheat marketing.

*The Chadbourne Plan of Sugar Control.*—Under this plan the principal sugar exporting countries entered into an agreement in May, 1931 to curtail exports of sugar. The countries concerned were Cuba, Java, Germany, Czecho-Slovakia, Poland, Hungary and Belgium. These countries represent about 40% of the world's output of sugar and approximately 90% of the exports. Peru and Jugo-Slavia joined in the agreement later in the year. The Chadbourne Plan not only limits exports to a quota but restricts production through the limitation of acreage. This scheme is administered by a permanent council known as the International Sugar Council with headquarters at the Hague. The objective has been to reduce sugar supplies gradually.

It was provided that the export quotas should be increased by 5% when the f.o.b. price of raw Cuban sugar should reach two cents per pound and maintain this level for thirty days. Further upward revision of export quotas was to be permitted as prices rose. An interesting arrangement was made whereby should Germany fail to export its quota in any year the shortage would be made up by an increase in exports from Cuba, Poland, Hungary and Czecho-Slovakia during the following year. Surplus stocks in each of the countries have been declared and these are to be reduced in annual installments.

The Chadbourne Plan has encountered some difficulties due to the decline in sugar consumption. The production of sugar has been curtailed but it is apparent that it has not yet been able to materially reduce accumulated stocks. It has, of course, three more years to demonstrate its effectiveness. The Cuban quota was revised upwards at a meeting of the Council in December, 1932 because of reduced exports to United States. The price level at which the first advance in quota can be made has been reduced to 1.75 cents f.o.b. Cuba, presumably because of the lower price quotations. This Plan has the support of the Governments of the countries concerned. It is, moreover, an attempt at international unity of action which is more difficult of accomplishment than national or regional unity.

*The Paterson Stabilization Plan.*—This plan has been applied in marketing Australian butter. It has been in operation since January 1, 1926. It had three objectives[6]: (1) to counteract the extra costs of production due to the accepted fiscal policy of Australia; (2) to aid in the disposal of surplus butter; (3) to stabilize butter prices in Australia. It should be stated that this scheme is a voluntary one and is administered by a Federal Stabilization Committee which is composed of representatives of both co-operative dairy marketing interests and private manufacturers. There is also an interstate committee with state branches. In 1926, under this arrangement, which is voluntary, a levy was made on all butter produced in factories in Australia except in the state of Western Australia. The amount of this levy was originally 1d. per pound but in 1928 it was raised to 1¾d. Out of this fund a bounty is paid on butter exported. The amount of the bounty has varied from year to year. At the outset it was 3d. When the levy was raised to 1¾d. the bounty was increased to 4d. A year later, January, 1929, it was raised to 4½d. and continued at this rate

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[5] Dolinsky, N. V. The agricultural situation in Bulgaria. Report to the International Conference of Agricultural Economists, 1933, p. 11

[6] Whitlam, A. G. Marketing Organization Annals of the Academy of Political Science, No. 158, November, 1931, p. 114.

until January 1, 1931, when it was reduced to 3½d. Three months later it was reduced to 3d., and a month later to 2½d. It was raised again to 3d. in April, 1932, and remains at this figure.

Australian dairymen claimed that they could not obtain domestic prices above "export parity" or world prices less the handling and freight charges, loss in transit, etc., to the United Kingdom and that their prices were as much as 3d. less than the "world rates". This three pence is what the Australians claim to be the difference between their costs of production and the prevailing London parity. It was said that such costs were materially increased by measures that have given a protected home market to other branches of industry. Therefore, the dairy industry was entitled to some measure of protection[7]. The bonus or bounty is not for the purpose of stimulating exports but for the purpose of providing compensation to exporters and thus enabling an estimated increase of 3d. per pound in the domestic price. To quote a recent opinion, "the direct result of the payment of an export bounty is that automatically, without any regulation, compulsion, or legislation the local price, through the operation of an economic law, rises to the level of the export price, plus the bounty paid"[8].

It is probable that in considering the claims of supporters of many of these schemes it would be necessary to speculate on what might have been had no control been exercised because most of them have operated for a short time during which there has been a general decline in prices.

The successful operation of this scheme is dependent on the consent of the Australian Government. For example, shortly after the scheme came into effect it was necessary to increase the tariff on butter imports. Moreover, consent of the Government is essential because it is believed that the plan contravenes the Australian Anti-Monopoly Law[9].

It should be pointed out that there has been an increase in production of butter in Australia. The output in 1925-26 was 273,314,000 pounds while in 1931-32 it had reached 390,512,000 pounds. Exports to the United Kingdom have increased rapidly. This has made the situation acute because of the extra amount which must be paid to exporters. It should be recognized that a variety of causes may be shown for the increase in butter production such as favourable grazing seasons, low prices of grain, improvement in pasture management, and shifting of land from wheat and wool production to dairying. Relative prices of agricultural products was another factor.

Besides the Paterson Plan there are several Export Control Boards in operation: for example, the Dried Fruits Control Board, the Canned Fruits Control Board, and the Dairy Produce Control Board which has acted as a regulating agency under statutory powers since 1925. There is, moreover, State legislation governing the Marketing of Primary Products to which reference will be made later on.

In this connection it should be pointed out that a recent decision of the Australian Supreme Court renders illegal an Act of Orderly Marketing which hampers the freedom of interstate traffic which is guaranteed by the constitution. This decision affects the operation of most of the Control Boards. It implies that both state and federal legislation is required and that State Boards may be set up under federal co-ordination[10]. In the case of butter it is proposed that the state governments should pass legislation whereby an export quota would be fixed by the State Control Board. At the time this is written it is not known how far this proposal has progressed but it suggests that the Paterson Plan may soon be superseded.

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[7] Brookens, P. F. The Paterson Plan and Australian butter prices. Journal of Farm Economics, Vol. X, No. 4, October 1928, pp. 540-543.

[8] Cooke, A. J. The Paterson scheme, Journal of the Department of Agriculture for South Australia, Vol. XXXVI, No. 3, October 15, 1932, p. 323.

[9] Edminster, L. R., Schaben, L. J., and Lynsky, M., F-S 56. Agricultural price supporting measures in in foreign countries. Bureau of Agricultural Economics, Washington, D.C., p. 25.

[10] Foreign Crops and Markets. Bureau of Agricultural Economics, U. S. Department of Agriculture, Washington, D.C., Vol. 27, No. 1, p. 8.

# SOME ASPECTS OF THE FARM TAX SITUATION IN ONTARIO[1]

S. C. Hudson[2]

Perhaps one of the most serious problems, arising out of the chaos of depression, by which agriculture is confronted is the farm tax situation. The inability of farmers to meet their taxes after obtaining even a meager living off their farms, is manifested by the large amount of arrears of taxes which has accumulated in almost every rural municipality.

To have a clear understanding of the present farm tax situation it is necessary to know something of taxation trends throughout the preceding period and to study the relationship of these trends to other economic factors. For this purpose an index number of farm taxes in Ontario was constructed, based on taxes levied in some 94 selected townships for the period 1906 to 1932. This index which is presented in Table 1 along with an index of the wholesale price of farm products for the period 1913 to 1932, shows that during the period under study, a very substantial increase in farm taxes in Ontario occurred, the highest peak being in 1930. In 1930 farm taxes were almost four times what they were in 1906 and about 2.75 times pre-war or 1913.

TABLE 1.—INDEX NUMBERS OF FARM TAXES IN ONTARIO 1906-1932[1] AND OF WHOLESALE PRICES OF FARM PRODUCTS 1913-1932[2]

(1926 = 100)

| Year | Farm Taxes | Prices of Farm Products |
|---|---|---|
| 1906 | 29.2 | – |
| 1907 | 31.4 | – |
| 1908 | 31.4 | – |
| 1909 | 32.4 | – |
| 1910 | 34.0 | – |
| 1911 | 35.8 | – |
| 1912 | 37.8 | – |
| 1913 | 42.0 | 62.6 |
| 1914 | 45.1 | 69.2 |
| 1915 | 51.2 | 77.7 |
| 1916 | 56.2 | 89.7 |
| 1917 | 63.3 | 130.0 |
| 1918 | 71.6 | 132.9 |
| 1919 | 70.7 | 145.5 |
| 1920 | 83.3 | 161.6 |
| 1921 | 88.2 | 102.8 |
| 1922 | 93.9 | 86.7 |
| 1923 | 95.3 | 79.8 |
| 1924 | 95.3 | 87.0 |
| 1925 | 97.1 | 100.4 |
| 1926 | 100.0 | 100.0 |
| 1927 | 104.6 | 102.1 |
| 1928 | 111.8 | 100.7 |
| 1929 | 114.4 | 100.8 |
| 1930 | 115.8 | 82.3 |
| 1931 | 108.0 | 56.3 |
| 1932 | 99.1 | 48.4 |

1 Municipal Statistics, Province of Ontario.

NOTE.—In the construction of the above index number of farm taxes for Ontario, two townships in each of 47 counties were selected. That territory commonly known as Northern Ontario, consisting of the counties of Cochrane, Kenora, Nippising, Rainy River, Sudbury, Thunder Bay and Temiskaming as well as much unorganized territory, was omitted due to shifts in municipal boundaries during the period as well as to the pioneer stage of agricultural development of the territory. Since township taxes include unincorporated villages an attempt was made in the selection of townships to select those having a minimum of non-agricultural population in order to minimize the error arising from this point. Attempt was also made to avoid, in so far as possible, those townships having public utilities upon which taxes are levied. While some discrepancy may arise from the points mentioned above, it is thought that an index constructed by this method should measure the trend of farm taxation with reasonable accurateness.

2 Prices & Price Indexes, Dominion Bureau of Statistics.

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[1] Preliminary statement, subject to revision.

[2] Field Assistant, Agricultural Economics Branch, Department of Agriculture, Ottawa.

The greatest increase is seen to have taken place between 1915 and 1922, there being a decided lag in rate of increase in 1919 and between 1922 and 1926, followed by a fairly rapid increase from 1926 to 1929, since which time there has been a marked decline, the index for 1932 being slightly lower than that for 1926.

Comparing the index of farm taxes with that of the wholesale price of farm products for the period 1913 to 1932 it is seen that from 1913 to 1922 taxes lagged behind farm prices and were not particularly burdensome. Between 1922 and 1924 due to a sharp decline in prices taxes became relatively higher. This relationship was changed somewhat in 1925 due to a rise in farm prices. During the period 1925 to 1929, taxes increased fairly rapidly while prices remained more or less constant. The collapse of prices of farm products from 100.8 in 1929 to 48.4 in 1932 was followed by a substantial decrease in taxes in the last two years. It is seen, therefore, that when prices rise, taxes rise less rapidly and, so long as this trend continues, the increased services demanded by the public may be paid for without difficulty. When, however, a fall in prices occurs, the demand for increased services remains. This demand, implemented by public borrowing, often causes a continuation of the upward trend of public expenditures for some years with the ultimate result that the reduction of taxes is made more difficult on account of financial obligations undertaken in previous years.

From an analysis of the taxes paid on 34 farms selected arbitrarily in a representative township of the County of Carleton for the period 1901 to 1931, at five-year intervals, changes in the distribution of the farmer's tax dollar were determined. This distribution, which is shown in Table 2, indicates a trend towards the county equalization of municipal expenditures.

TABLE 2.—DISTRIBUTION OF THE FARMER'S TAX DOLLAR BY FIVE-YEAR PERIODS 1901-1931

| Year | County Purposes | Township Purposes | School Purposes | Total Taxes |
|---|---|---|---|---|
| 1901 | 24.6 | 31 4 | 44.0 | 100.0 |
| 1906 | 23.8 | 33.2 | 43.0 | 100.0 |
| 1911 | 22.7 | 31.6 | 45.7 | 100.0 |
| 1916 | 33.6 | 25.2 | 41.2 | 100.0 |
| 1921 | 33.2 | 35.2 | 31.6 | 100 0 |
| 1926 | 46.8 | 23.8 | 29.4 | 100.0 |
| 1931 | 57.5 | 17.8 | 24.7 | 100.0 |

While from 1901 to 1911 about 44% of the levy was for school purposes, with less than 25% for county purposes, in 1916 an increased proportion is seen to have been appropriated for county purposes. Since the analysis of the 1931 tax levy shows that over 57% of the farmer's tax dollar is for county purposes, with about 18% and 25% for township and school purposes respectively, it would seem that an analysis of county expenditures and sources of revenue should indicate the factors causing the major part of the increase in taxes.

For the purpose of studying county receipts and expenditures, the United Counties of Stormont, Dundas and Glengarry were selected as being representative of the major part of Ontario.

TABLE 3.—TREND OF EXPENDITURES OF THE UNITED COUNTIES OF STORMONT, DUNDAS AND GLENGARRY BY FIVE-YEAR PERIODS IN TERMS OF THE PERIOD 1902-06

| Item of Expense | Per cent of Expenditures for 1902-06 | | | | |
|---|---|---|---|---|---|
| | 1907-11 | 1912-16 | 1917-21 | 1922-26 | 1927-31 |
| Administration | 107.1 | 139 2 | 187.1 | 201.4 | 239.5 |
| Protection and Administration of Justice | 98.3 | 111.6 | 124.0 | 146.7 | 211.5 |
| Education | 174 6 | 214 0 | 357.7 | 719.2 | 858.8 |
| Highways | 108.5 | 51.4 | 1,286.4 | 1,211.9 | 901.2 |
| Welfare | 1,297 0 | 1,797 5 | 647 8 | 1,273 1 | 3,603 6 |
| Miscellaneous* | 78.6 | 376.3 | 835 8 | 323.5 | 314 2 |
| All items | 140 8 | 282 6 | 1,306 2 | 1,400.9 | 1,372 8 |

* Includes non-resident land tax, special grants, interest, drainage, war tax, county property, etc.

TABLE 4.—DISTRIBUTION OF EXPENDITURES OF UNITED COUNTIES OF STORMONT, DUNDAS AND GLENGARRY BY FIVE-YEAR PERIODS 1902-31

| Item of Expense | 1902-06 | 1907-11 | 1912-16 | 1917-21 | 1922-26 | 1927-31 |
|---|---|---|---|---|---|---|
| Administration | 11 3 | 8 6 | 5 6 | 1 6 | 1 6 | 2 0 |
| Protection and Administration of Justice | 19 7 | 13 7 | 7 8 | 1 9 | 2 1 | 3 0 |
| Education | 48 7 | 60 4 | 36 9 | 13 3 | 24 9 | 30 4 |
| Highways | 7 4 | 5 7 | 1 4 | 72 8 | 63 9 | 48 5 |
| Welfare | .5 | 4 6 | 31 9 | 2 5 | 4 6 | 13 2 |
| Special grants | 2 3 | 2 5 | 6 5 | 4 5 | 7 | .4 |
| War Tax | — | — | 7 8 | 1 7 | — | — |
| Miscellaneous* | 10.1 | 4 5 | 2 1 | 1 7 | 2 2 | 2.5 |
| Totals | 100.0 | 100 0 | 100 0 | 100 0 | 100 0 | 100.0 |

* Includes non-resident land tax, interest, drainage, county property, etc.

Tables 3 and 4, in which the expenditures of the United Counties of Stormont, Dundas and Glengarry from 1902 to 1931 are analysed by five-year periods, show the relative importance of each item of expenditure for each period. While in the early periods administration, protection and administration of justice, and education were the principal items of expenditure, the additional service taken on by the counties during the later periods reduced the first two of these items to relative insignificance. Throughout the period, however, education has remained one of the principal items of expense, being surpassed only by highways following the period 1917-21.

During the period 1912-1916 the expenditures for welfare, which includes care of indigents and lunatics and grants to hospital and other charitable institutions, was relatively high due to large capital expenditures for the establishment of a House of Industry, and on this account may be misleading. During the same period special grants, which include grants for patriotic purposes, and special war taxes made up a relatively large part of the total expenditure.

Following the war, due to the abnormal progress in the field of motor transportation, there was a general demand for improved highways. The consequence of this demand is indicated in the fact that for the period 1917 to 1921 over 70% of county expenditures was for highway purposes. This was followed by a slight decrease in the following period, while for the most recent period expenditures for highway purposes made up about 48% of total expenditures.

The provision of additional social services, such as Mothers' Allowance and Old Age Pensions as well as increased expenditures for the care of the indigent due to depressed economic conditions, is reflected in the increase in welfare expenditure during the last two periods.

Changes in the sources of revenue from which the funds for these increased expenditures were obtained are shown in Table 5.

TABLE 5.—DISTRIBUTION OF RECEIPTS OF THE UNITED COUNTIES OF STORMONT, DUNDAS AND GLENGARRY BY FIVE-YEAR PERIODS 1902-31

| Source of Revenue | 1902-06 | 1907-11 | 1912-16 | 1917-21 | 1922-26 | 1927-31 |
|---|---|---|---|---|---|---|
| County Rates | 73.6 | 69.2 | 72.7 | 60.5 | 54.2 | 66.7 |
| Provincial Government Grants | | | | | | |
| Administration of Justice | 6.7 | 3.6 | 3.2 | .5 | .5 | .8 |
| Education | 15.0 | 23.6 | 20.2 | 10.6 | 12.8 | 12.3 |
| Highways | — | — | — | 26.6 | 30.9 | 16.0 |
| Other Sources* | 4.7 | 3.6 | 3.9 | 1.8 | 1.6 | 4.2 |
| Totals | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

* Includes licenses, fines, registry office fees, non-resident land taxes, division court jury fund, miscellaneou refunds, house of refuge, hospitals, etc.

While during the period 1902-1906 about 74% of county revenue came from the counties' portion of the general property tax levied by the municipalities constituting the counties, this proportion decreased during the succeeding years until it was 54% in the period 1922-26. Due largely to the decrease in provincial grants for highway purposes during the following period the proportion of the total revenue contributed by the townships increased to about 67%. The data presented in this table, however, indicate a trend in the direction of provincial distribution of municipal expenditures.

It would seem then, that the present farm tax situation is the normal result of a collapse in prices following a period of high prices during which an insatiable demand for additional services was developed, and is due primarily to an unstable or deflated price level.

Co-operative Marketing was the subject of much discussion at the Annual Extension Conference to be held at the Agricultural College, Truro, Nova Scotia, January 2nd - 5th, 1934.

Plans are under way in Australia whereby state and Commonwealth legislation is proposed to authorize the setting up of a new butter marketing plan which will supplant the Patterson Scheme which has been in operation for several years and which has not proven to be adequate under present conditions. Moreover the Dairy Produce Control Act has been declared to be *ultra vires* and the new legislation is designed to overcome objections to the former method of control.

# THE COST OF MANUFACTURING CHEESE IN ONTARIO

J. F. BOOTH[1] and C. V. PARKER[2]

This is the first of a series of articles dealing with the economic side of the manufacture of cheese. The data contained in this article were collected in the fall of 1932, and apply to the 1931 operations of 125 Ontario cheese factories. A similar study, comprising 120 factories in the Province of Quebec, was undertaken at the same time, the results of which will be discussed in a later issue of *The Annalist.*

Officials of the Dairy and Economics Branches of the Dominion Department of Agriculture co-operated with the Provincial authorities in the conduct of both studies. In Quebec the authorities were the Animal Husbandry Branch and the Rural Economics Branch of the Department of Agriculture. In Ontario the co-operating agencies were the Dairy Branch of the Ontario Department of Argiculture and the Economics Department of the Ontario Agricultural College.

In this article, the costs of factory operation will be dealt with and in those following other phases will be discussed.

The problems facing the cheese industry in Ontario today are many. Perhaps the most important one affecting production costs, however, is declining volume of business. In 1864 the first cheese factory is reported to have been established in Oxford County, Ontario. From then on a rapid development took place in the industry until early in this century. Since the 1900-04 period there has been a gradual decline in production of cheese in Ontario (and in fact throughout the whole Dominion). In1931, Ontario had 714 factories in which were produced slightly over 84 million pounds of cheese. This figure represents a decrease of 36.4% as compared to a production of nearly 132 million pounds in the year 1900.

With the development of large urban centres and increased demand for milk for fluid consumption and for use in the manufacture of other dairy products the production of cheese declined. Parallelling this development came improved means of transportation, better roads and more suitable means of handling milk, the net effect of this combination of circumstances being increased competition and declining volume of business for cheese factories. It has been difficult for operators of cheese factories to cope with these changed conditions and thus compete with other users of milk.

Milk for cheese production must be delivered each morning and must be clean and cool to make good cheese. Therefore in the establishment of factories it has been necessary always to give consideration to the distance milk could be hauled. In the early period of development, and even yet in most areas, that meant the distance that a patron could haul his milk in a horse drawn vehicle each morning. In consequence the area served by a given factory, particularly in Eastern and Central Ontario, was comparatively small and the distance between factories often but a few miles.

It is believed that the presentation of cost of production figures for factories of different sizes will be of some value to those interested in the cheese factory business in Ontario.

*Costs of Manufacturing Cheese.*—In the accompanying tables costs are given according to two methods of calculation. Charges for hauling milk to the factory and cheese from the factory are not included.

In Method I, costs were figured from the viewpoint of what it cost the patron. It represents the "actual rates" charged, i.e., the charges made by private owners and the set deductions owners of patron factories make from the sale price of the cheese. In addition, patron organization costs—salaries, stationery and milk testing were added to the rates for privately owned factories. Method I, then, deals with costs as the patron thinks of them. It represents in a sense their annual "out of pocket" expense.

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TABLE 1.—COMPARISON OF ACTUAL AND TOTAL CHARGES AND EFFECT OF VOLUME ON COST OF CHEESE MANUFACTURE

| Size of factory (tons of cheese) | Method I. Actual rates charged | | Method 2. Cost of operation including full charges | | Difference between two methods |
|---|---|---|---|---|---|
| | No. of factories | Cost per pound | No. of factories | Cost per pound | |
| Under 25 | 4 | 2 34 | 6 | 2 98 | .64 |
| 25 - 49.9 | 29 | 2.09 | 35 | 2 58 | .49 |
| 50 - 74.9 | 25 | 2 13 | 37 | 2 36 | .23 |
| 75 - 99.9 | 8 | 2 12 | 11 | 2.14 | .02 |
| 100 - 124.9 | 6 | 1.87 | 12 | 2 12 | .25 |
| 125 - 149.9 | 5 | 1.78 | 7 | 2 00 | .22 |
| 150 - 174.9 | 7 | 1 78 | 8 | 1.96 | .18 |
| 175 and over | 6 | 1 75 | 9 | 1 82 | .07 |
| All factories | 90 | 1.94 | 125 | 2 16 | 22 |

In Table 1, factories are classified according to tons of cheese produced and costs for each size group are given according to both methods of computation. The average cost per pound for Method I was 1.94 cents in 1931. It varied from 2.34 cents for small factories to 1.75 cents for the largest plants.

It was found on examining the costs as worked out by Method I that all charges were not fully met. Factory owners, as a rule, did not make adequate allowance for depreciation in arriving at the rates to be charged for cheese production, and consequently their labour returns were lowered. The same can be said of patron owned plants; patrons actually lost part of their capital by not adequately covering depreciation. The general practice in cheese factories is to meet replacement costs as they occur but in 1931 when retrenchment was taking place, many factory owners probably spent less than usual on capital items. It was found that expenditures to meet depreciation (i.e., new equipment for replacement purposes and reconstruction of buildings) amounted to only 25% of the estimated depreciation charges for that year. Some factory owners spent more than others and, of course, the rates of depreciation do vary in different factories. In order, however, to place all concerns on the same basis and also to take into consideration all the costs incurred in factory operation Method II was adopted. These costs are also presented in Table 1.

For both patron and privately owned factories the costs listed under Method II fell into three categories: (1) the actual cash operating expenses (excluding capital expense and wages to maker) shown on the same basis for both types of factories; (2) interest on capital invested was charged at 5%, depreciation on frame buildings at 5% and on brick or stone structures at 3% of the present value, and depreciation on equipment was calculated on the "years future use" basis; present values and years future use were obtained for the major items of equipment; by dividing the years future use into the present value a depreciation figure for the year of the study was obtained; (3) the salaries for makers were arrived at by deducting their expenses from the amounts they received for making cheese.

Turning to Table 1 again it may be seen that the average cost per pound for manufacturing cheese was 2.16 cents when all charges were taken into account. A comparison of the rates according to both methods of computation reveals that larger factories were meeting all charges more fully than were the smaller plants. Apart from the smallest group of factories which had a cost of 2.34 cents per pound, the rates according to Method I (actual rates charged) were around 2⅛ cents per pound for factories producing under 100 tons of cheese. A large decrease in actual rates charged occurred between the 75-99.9 ton and 100-124.9 ton group. This was followed by a smaller decrease in the next size group and from there on average rates remained practically the same.

The rates according to Method II were very much higher than actual rates in the first three size groups of factories but they were practically the same for the 75-99.9 ton group. Therefore, if an actual rate of 2-2⅛ cents is to be charged, total costs will be met only when an output of 75 tons or more is reached. Similarly, if 1.87 to 1.75 cents per pound is to be charged, all expenses can only be met by producing over 175 tons of cheese per factory.

*The Effect of Volume on Costs.*—Besides portraying the differences in costs between Methods I and II, Table 1 also shows the effect of volume on costs of production. The total cost for factories producing under 25 tons of cheese was 2.98 cents per pound. With each increase in the volume of production a decrease in the rate or cost per pound took place. In the largest producing group, 175 tons and over, the rate was 1.82 cents. In all, a decrease in costs of 1.16 cents per pound was recorded. Economy in producing cheese is thus clearly linked up with volume of production.

The costs presented in Table 1, Method II, are given in considerably more detail in Table 2. Here, the effect of volume on various items of expense is clearly shown. The cost per pound attributable to boxes, supplies and fuel did not decrease appreciably with increases in size of factory for reasons more or less obvious. However, in the larger factories there was a decided reduction per pound when so-called fixed charges—taxes, insurance, interest and depreciation—were considered. Although hired

TABLE 2.—COST PER POUND OF CHEESE OF MAIN ITEMS OF EXPENSES BY SIZE OF FACTORY

| Main items of expense | Size of factory — Cents per pound of cheese | | | | | | | | All factories |
|---|---|---|---|---|---|---|---|---|---|
| | Under 25 tons | 25 to 49 9 | 50 to 74.9 | 75 to 99.9 | 100 to 124 9 | 125 to 149 9 | 150 to 174.9 | 175 and over | |
| Boxes | 297 | 286 | 287 | 270 | 345 | 312 | 315 | .321 | .306 |
| Supplies | .304 | 304 | 268 | 280 | 255 | .223 | 274 | .248 | .265 |
| Fuel | .310 | 211 | 241 | .235 | .255 | 255 | .273 | 235 | .248 |
| Taxes and Insurance | .093 | .103 | 089 | 083 | 064 | 062 | .054 | .051 | .072 |
| Organization salaries | 147 | 082 | 083 | 084 | 055 | 062 | .042 | .063 | .069 |
| Hired labour and board | 001 | .113 | 188 | 190 | .374 | 350 | .382 | .397 | 281 |
| Maker's salary | 1 245 | .974 | 810 | 678 | 522 | 489 | 405 | .414 | .628 |
| Other factory expenses | .048 | 041 | .038 | 038 | .039 | 038 | .032 | .041 | .039 |
| Repairs | 073 | 088 | 083 | 086 | 127 | 073 | .060 | .077 | .080 |
| Interest | 187 | .180 | 167 | 157 | 137 | .148 | .148 | .086 | .144 |
| Depreciation | .305 | .286 | 252 | .271 | 218 | .212 | .193 | .125 | .218 |
| Gross expenses | 3 010 | 2 665 | 2 505 | 2.374 | 2 392 | 2.223 | 2.184 | 2.055 | 2 349 |
| Whey credit | 030 | .088 | 143 | 229 | .271 | .224 | .219 | .231 | .194 |
| Net expense | 2 98 | 2.58 | 2 36 | 2 14 | 2 12 | 2 00 | 1.96 | 1.82 | 2.16 |
| No. of factories | 6 | 35 | 37 | 11 | 12 | 7 | 8 | 9 | 125 |

Note: In the handling of the whey product costs it was agreed to include that portion of the receipts received by the maker as a charge to the factory business. To offset this charge, and thus arrive at the cost of manufacturing cheese, the remaining portion of the receipts (the amount received by the patrons), was deducted from the total expense. The net expense thus obtained was divided by the number of pounds of cheese manufactured in order to obtain the cost per pound.

TABLE 3.—RANGE OF COSTS PER POUND FOR MANUFACTURING CHEESE

| Costs (cents per pound) | Number in class | Weighted average for each class | Percentage Distribution |
|---|---|---|---|
| Under 1.60 | 1 | 1.59 | .8 |
| 1.60 - 174 | 4 | 1.65 | 3.2 |
| 1.75 - 1.99 | 19 | 1.87 | 15.2 |
| 2.00 - 2.24 | 29 | 2.13 | 23.2 |
| 2.25 - 2.49 | 34 | 2.35 | 27.2 |
| 2.50 - 2.74 | 19 | 2.61 | 15.2 |
| 2.75 - 2.99 | 11 | 2.85 | 8.8 |
| 3.00 - 3.24 | 7 | 3.11 | 5.6 |
| 3.25 and over | 1 | 3.27 | .8 |
| Total or average | 125 | 2.16 | 100.0 |

labour costs (other than maker) increased with volume of production the amount paid to cheese makers, when computed on a per pound basis, decreased rapidly with increases in volume of production. Thus larger concerns were much more efficient in the use of the largest expense item in factory costs.

In Table 3 costs are presented in a slightly different way. Here, the factories are arranged in groups according to costs of operation and it will be observed that the extremes were 1.59 cents per pound in one factory and 3.27 cents in another. This difference was due almost entirely to the much larger volume of business handled in the low cost factory. About 50% of the factories were within the group represented by costs ranging from 2.00 cents to 2.50 cents per pound.

*Summary and Conclusions.*—The cost of manufacturing cheese is closely related to output. The extreme difference in costs between the highest and lowest cost factories was 1.68 cents per pound or the equivalent of about 15 cents per hundred pounds of milk. At prices prevailing in 1931 this represents a difference of about 20%. The difference between the costs incurred in the group of factories producing less than 25 tons annually and those of factories with an average output of 175 tons per year was 1.16 cents or approximately 10 cents per hundredweight of milk.

This large reduction in costs was achieved by making maximum use of labour, plant and equipment, and since, in this business, any benefit thus obtained is reflected directly in the price paid for milk, it would appear desirable to increase the volume of business wherever possible. In many cases this could best be achieved by the amalgamation of factory districts and the closing of unnecessary factories. This, in turn, would mean longer hauls by patrons, or, if the conditions of roads permitted, the organization of milk routes.

Where the conditions of roads do not permit of the hauling of heavy loads such as would be necessary if milk routes were organized and where patrons do not wish to haul their own milk longer distances, increased volume would have to be obtained by lengthening the period of operation, by increasing the size of herds and production per cow or by diverting milk which now goes to city milk plants, creameries or condensaries.

It is appreciated that there are other things to consider in connection with factory amalgamation. Nevertheless, there are many cases where the area served by a factory could advantageously be enlarged, and patrons would be well advised to give careful thought to the question.

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The Journal of the Ministry of Agriculture, December, 1933, reports that the Hops Marketing Board has placed valuations on representative samples of the 1933 crop. Trading opened on October 30th; the Board has been able to dispose of considerable quantities at prices within the values established. The Brewing Industry has, however, issued a formal complaint against the Board's operation and the matter has been referred to a Committee of Investigation.

# ECONOMIC LITERATURE

**F. M. Clement.** Report on the Enquiry Conducted on Behalf of Six Locals of the Associated Growers of British Columbia Limited, 1933.

This report covers "some aspects of the relations of the Southern Locals of the Associated Growers of British Columbia Limited as compared with the Northern Districts, and the marketing problems confronting the co-operative producers of Fruit and Vegetables in the Okanagan Valley of British Columbia." The report gives a detailed and thorough outline of the operations of the Associated Growers' Central and Local organizations. Opinions expressed by growers and officers have been used freely, and together with the author's opinions and recommendations, a very concise picture of the industry has been presented.

Space does not permit of the presentation of all the difficulties to be overcome that are mentioned in the report; the following summary contains a few of them.

The problem is that "a certain feeling of dissatisfaction is evident" among growers . . . . "Dissatisfaction with the Central (organization) is not only wide-spread and deep, but at times among some of the membership is critical up to a point of distrust. On the other hand, a similar review indicates that there is relatively little criticism of the locals, their management or their directors." In the author's opinion the locals are not entirely blameless. Each local believes that it enjoys special advantages that other locals do not enjoy and in a spirit of "self-determination" endeavours to capitalize these advantages. Speaking broadly, "the local expects the Central to sell all products produced, regardless of quality or grade, at a price which is remunerative to the grower."

The Central, on the other hand, "naturally feels that a better showing could be made if they could select the tonnage according to market demand. They feel that the locals should be subject to some dictation, if not control."

The duties of the Central have been made particularly hard due to the changing business organization in the prairie markets during the last few years. Business connections with large distributing firms are important "if the tonnage of any one large packing company is to be placed to advantage." The changes in the distributive "set-up" on the prairies, as listed in the report, have had far-reaching effects on the sales policy of the Central.

At the outset the Associated was a "Save the Industry" organization. It came into being in 1923 following two years of disastrous prices. "The organization campaign aimed at 100% control. At no time however, did the Associated control more than 85% of the tonnage. The ideas of stabilization and price regulations were fundamental to the organized campaign." Tonnage control fell from 85% in 1923 to 40% in 1933, but "the idea of stabilization persisted." The failure of the Board to realize earlier that less than 100% control could not stabilize the market is, in the opinion of the author, the fundamental cause of dissatisfaction at the present time.

However, the Board of Directors now recognizes it's functions to be: (1) to obtain a competitive price for their growers, and (2) to join whole-heartedly any reasonably sound plan for price regulation and stabilization of the industry as a whole.

In summing up, the author's main recommendations were as follows:

(1) "That no change be made at the present time in relation to Central Selling; that all assets be preserved but that such changes as are necessary be made to make the machine operate more efficiently . . . . in the interest of the membership."

(2) "That, as a general policy for operation, you consider operating as an independent business concern made up of co-operative growers and distributors."

(3) "That every man be paid all that his particular grade and quality of product will bring—without 'sweetening or penalty' direct or indirect in any pool."

(4) "That zone pooling be inaugurated if desired by the locals."

(5) "That you recognize the principle of "selective co-operation;" .... and that there should be a limit to the time a grower could continue to produce certain varieties and grades and expect the local to pack and the Central to sell them."

(6) "That Central and all locals be put on a budget basis; the budget to be based on the expenditures of the past."

(7) "That since the idea of 'save the industry' is not now the first responsibility of the Associated, all activities in assisting and selling for organizations outside of the Valley be discontinued unless full costs for such operations are paid for ...."

(8) "That the cold storage plants be recognized as an important and integral part of the industry that is essential to every variety of apples ...."

(9) "That British Columbia except (for the present) Vancouver, Victoria, New Westminster and Prince Rupert, be recognized as open markets for competitive operation on the part of locals or on the part of truckers supplied by locals. That after due consideration certain towns, large and small in Southern Alberta and Southern Saskatchewan be recognized as open markets as well."

This Report is not available for general distribution.

## NOTES

In the Province of Quebec new rules have been instituted regarding the transportation of milk and cream from the producer to the distributor. Transportation by any motor or animal driven vehicle of milk or cream is only authorized between 5 and 10 o'clock in the morning, standard time, between May 1 and November 1. On Saturday evenings, however, milk or cream may be transported to country factories between 5 and 9 o'clock standard time during the same period. From November 1 to May 1, transportation is allowed only between 5 a.m. and 1 p.m. and on Saturdays between 5 p.m. and 9 p.m.

Preliminary arrangements for a world-wide minimum scale of wheat prices are to be presented to the International Wheat Commission on January 22, 1934, by a marketing committee of that organization. The committee does not hope to go further than to suggest what should be the price differentials for the various kinds of wheat and it will be left to the Commission to decide the actual prices. Delegates from big wheat-producing nations are convinced that a minimum scale is necessary for two or three months to tide wheat over from its current low ebb in the world's market.

J. F. Booth, Department of Agriculture, Ottawa, J. E. Lattimer, Macdonald College, P.Q., and T. W. Grindley, Dominion Bureau of Statistics, Ottawa, have been appointed by the National Advisory Committee on Agricultural Services to formulate plans for the presentation of an agricultural outlook report for Canada.

A meeting of the Joint Federal-Provincial Committee on Agricultural Economics for Ontario was held in Toronto, November 27th and 28th. This was the third meeting of the Committee which was constituted in 1931 at a Conference called by the Ministers of Agriculture of the respective departments to devise ways and means of handling the urgent problems facing agriculture. One of the purposes of the Committee has been to eliminate overlapping of effort and duplication of work. To that end the various agencies interested in agricultural economics and allied fields of work reviewed what was being done and considered projects that should be undertaken. The co-operation of Departments of Agriculture, Bureau of Statistics, Universities and Colleges interested in Ontario agriculture has been furthered by the work of this Committee. Those attending the recent meeting and the organizations represented were as follows: W. B. Somerset, Ontario Marketing Board, Toronto; Geo. Barr and J. A. Carroll, Department of Agriculture, Toronto; Professors F. C. Hart and C. W. Riley, Ontario Agricultural College, E. E. Rielly, Western University and W. R. Drummond, Toronto University; Dr. J. F. Booth, J. Coke, R. L. Wheeler, P. E. Light, Dominion Department of Agriculture; Dr. T. W. Grindley, Dominion Bureau of Statistics.

L'ECONOMISTE AGRICOLE

REVUE TRIMESTRIELLE DE L'INDUSTRIE AGRICOLE PUBLIEE PAR
LA DIVISION DE L'ECONOMIE AGRICOLE, MINISTERE
FEDERAL DE L'AGRICULTURE, OTTAWA

Vol, III. Nos. 10, 11, 12. Oct., nov., déc., 1933

# LA SITUATION ECONOMIQUE

PREPARE PAR LA DIVISION DE L'ECONOMIE AGRICOLE DU MINISTERE DE L'AGRICULTURE, OTTAWA, ET BASE SUR LES DONNEES RECUEILLIES PAR LE BUREAU FEDERAL DE LA STATISTIQUE

Les prix de gros au Canada se sont relevés au cours de novembre. L'indice compilé par le Bureau fédéral de la statistique était de 68.7 contre 67.9 en octobre. Les hausses ont porté sur les groupes suivants: légumes et leurs produits, animaux et leurs produits, bois, produits de bois et papier, fer et ses produits, et les métaux non ferreux et leurs produits. Par contre, les fibres, les textiles et les produits textiles, les minéraux non métalliques et leurs produits et les produits chimiques et de même nature ont rétrogradé.

*Prix de détail.*—De 77.9 qu'il était en octobre, l'indice des prix de détail, des loyers et des frais de services, s'est élevé à 78.1 en novembre. Cette avance est due principalement à une hausse des prix des aliments et, à un moindre degré, à une hausse dans l'indice du combustible.

*Embauchage.*—L'indice de l'embauchage, qui était de 88.4 au 1er novembre, est passé à 90.9 au 1er décembre. C'est là une avance de près de 8 points sur l'indice du 1er décembre 1932.

*Volume physique des affaires.*—L'indice du volume physique des affaires est tombé à 85.5 en novembre; celui de la production industrielle de 87.4 à 83.9; celui des industries manufacturières, de 87.9 à 86.2. Par contre, l'indice de l'industrie forestière est monté de 86.2 à 87.2. La production du fer et de l'acier est tombée de 37.3 à 33.4; le bâtiment de 42.6 à 37.3. La production de l'énergie électrique est montée de 148.8 à 158.1. Les importations ont été plus considérables, mais l'indice des exportations a baissé.

*Produits agricoles.*—Les prix des produits de ferme canadiens ont monté en novembre. L'indice des produits des champs s'est élevé de 44.6 à 46.7, celui des produits animaux de 62.8 à 65.8. L'indice total est donc passé de 51.4 en octobre à 53.8 en novembre. Le dernier prix moyen du blé du Nord Manitobain No. 1, à Fort William, était de 60.5c. le boisseau en octobre, contre 63.7c. en novembre. Les prix de l'orge, de l'avoine, du lin et du seigle ont un peu remonté. On a obtenu de meilleurs prix pour les boeufs, les porcs, les moutons, les agneaux, le lait, les oeufs et la laine, et l'indice des animaux et de leurs produits s'est élevé de trois points. Les prix des produits de ferme sont encore très bas, mais il est à noter qu'à tout prendre la courbe de ces prix n'a cessé de monter en 1933.

Les ventes agricoles ont été bien inférieures à celles d'octobre. L'indice des ventes de grain est tombé de 70.0 à 36.7, l'indice du blé de 75.6 à 40.1 et celui de l'avoine de 97.2 à 35.9. Il ne s'est transporté que relativement peu d'orge, de lin ou de seigle. L'indice total est donc tombé de 70.5 en octobre à 41.8 en novembre.

Les ventes de bestiaux se sont mieux maintenues que celles du grain. L'indice des ventes de boeufs, qui était de 56.2, est tombé à 50.7. Chez les porcs, la baisse a été de 93.6 à 88.0, chez les moutons de 98.8 à 61.7. Il y a eu une forte réduction dans le mouvement des veaux, l'indice qui était de 102.8 en octobre est tombé à 89.9 en novembre. L'indice total est donc descendu à 41.8.

### CHIFFRES-INDICES, ANNUELS ET MENSUELS, DES PRIX ET DE LA PRODUCTION COMPUTES PAR LE BUREAU FEDERAL DE LA STATISTIQUE

| Année | Prix de gros 1926 = 100 | | | | Prix de détail et coût des services (5) | Production (6) 1926 = 100 | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Tous produits (1) | Produits de ferme (2) | Produits des champs (3) | Produits animaux (4) | | Volume physique des affaires | Production industrielle | Ventes de produits agricoles | Produits en entrepôts froids |
| 1913.... | 64.0 | 62.6 | 56.4 | 77.0 | 65 4 | .... | .... | .... | .... |
| 1914. .. | 65.5 | 69.2 | 64.9 | 79.0 | 66.0 | .... | .... | .... | .... |
| 1915... | 70.4 | 77.7 | 76.9 | 79.2 | 67.3 | .... | .... | .... | .... |
| 1916.... | 84.3 | 89.7 | 88.4 | 92.3 | 72.5 | .... | .... | .... | .... |
| 1917... | 114.3 | 130.0 | 134.3 | 119.6 | 85.6 | .... | .... | .... | .... |
| 1918.... | 127.4 | 132.9 | 132.0 | 134.7 | 97.4 | .... | .... | .... | .... |
| 1919.... | 134.0 | 145.5 | 142.4 | 152.5 | 107.2 | 71.3 | 65.5 | 48.1 | 47.1 |
| 1920.... | 155.9 | 161.6 | 166.5 | 149.9 | 124.2 | 75.0 | 69.9 | 52.6 | 94.2 |
| 1921.... | 110.0 | 102.8 | 100.3 | 108.5 | 109.2 | 66.5 | 60.4 | 65.2 | 86.4 |
| 1922.... | 97.3 | 86.7 | 81.3 | 99.1 | 100.0 | 79.1 | 76.9 | 82.6 | 82.8 |
| 1923.... | 98.0 | 79.8 | 73.3 | 95.1 | 100.0 | 85.5 | 83.8 | 91.4 | 87.6 |
| 1924.... | 99 4 | 87 0 | 82 6 | 97.2 | 98.0 | 84.6 | 82.4 | 102.5 | 114.9 |
| 1925.... | 102.6 | 100 4 | 98.1 | 105.7 | 99.3 | 90.9 | 89.7 | 97.2 | 108.6 |
| 1926.... | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.9 | 100.0 |
| 1927.... | 97.7 | 102.1 | 99.9 | 105.7 | 98.4 | 106.1 | 105.6 | 103.6 | 110.0 |
| 1928.... | 96.4 | 100.7 | 92.6 | 114.3 | 98.9 | 117.3 | 117.8 | 146.7 | 112.8 |
| 1929... | 95.6 | 100.8 | 93.8 | 112.5 | 99.9 | 125 5 | 127.4 | 101.1 | 109.6 |
| 1930.... | 86.6 | 82.3 | 70.0 | 102.9 | 99 2 | 109.5 | 108.0 | 103.0 | 128.4 |
| 1931.... | 72.2 | 56.3 | 43.6 | 77.6 | 89.6 | 93.5 | 90.4 | 99.0 | 125.7 |
| 1932.... | 66.7 | 48.4 | 41.1 | 60.7 | 81.4 | 78.7 | 74.0 | 114.3 | 120.1 |
| 1933 | | | | | | | | | |
| Jan..... | 63.0 | 43.6 | 35.1 | 57.9 | 79.1 | 68.1 | 62.2 | 56.1 | 112.0 |
| Fév..... | 63.6 | 43.0 | 36.0 | 54.7 | 78.4 | 67.0 | 60.0 | 76.5 | 127.6 |
| Mars... | 64.4 | 44.7 | 38.0 | 56.0 | 77.8 | 68.4 | 62.5 | 129.0 | 135.8 |
| Avril... | 65.4 | 46.8 | 41.1 | 56.4 | 78.1 | 69.8 | 65.1 | 104.1 | 112.7 |
| Mai.... | 66.9 | 51.2 | 46.9 | 58.4 | 77.0 | 76.4 | 72.7 | 95.4 | 100.4 |
| Juin.... | 67.6 | 52.6 | 49.4 | 57.9 | 77.0 | 82.2 | 79.8 | 221.9 | 119.9 |
| Juillet . | 70.5 | 60.1 | 60.8 | 59.0 | 77.2 | 84.1 | 82.6 | 221.9 | 119.9 |
| Août ... | 69.4 | 57.0 | 54.9 | 60.5 | 78.6 | 89.8 | 89.5 | 197.2 | 114.2 |
| Sept... | 68.9 | 54.7 | 49.5 | 63.4 | 78.8 | 90.8 | 90 2 | 101.1 | 115.7 |
| Oct.. . | 67.9 | 51.4 | 44.6 | 62.8 | 77 9 | 88.2 | 87.4 | 70.5 | 112.7 |
| Nov... . | 68.7 | 53.8 | 46.7 | 65.8 | 78.1 | 85.5 | 83.9 | 41.8 | 111.1 |

1. Voir Prix et Indices des prix, 1913-1928, pages 19-21, 270-289 et 1913-1931, page 15.

2. Prix de gros des produits de ferme canadiens. Voir Prix et Indices des prix, 1913-1931, page 33, et miméographes mensuels 1932 et 1933.

3. Prix de gros des grains, fruits et légumes.

4. Prix de gros des animaux et des produits animaux.

5. Y compris la nourriture, le loyer, le combustible, les vêtements et objets divers. Voir Prix et Indices des prix, 1913-1928, pages 181-185, 290-293. 1926 = 100.

Prix et Indices des prix, 1913-1931, page 122, et miméographes mensuels, 1932-1933.

6. Revue mensuelle de la statistique commerciale, page 8 et indices mensuels du volume physique des affaires au Canada. Supplément à la Revue mensuelle de la Statistique commerciale, novembre 1932.

L'indice des produits conservés au froid était un peu plus bas en novembre. Les stocks d'oeufs, de saindoux et de fromage étaient un peu plus élevés qu'en octobre, mais ceux des autres produits étaient un peu plus bas que le mois précédent. C'est dans les approvisionnements de mouton que le changement le plus considérable a été enregistré.

*Récoltes des champs.*—La section agricole du Bureau fédéral de la statistique a publié dernièrement son bulletin annuel de l'étendue ensemencée en récoltes de grande culture. Un fait intéressant à noter, c'est que l'étendue totale a été réduite de plus d'un million d'acres. L'étendue ensemencée en 1932 était de 57,734,000 acres, tandis qu'elle était de 56,580,550 acres en 1933. L'étendue totale en blé, qui était de 27,182,000 acres, a été réduite à 25,991,100 acres. L'étendue en avoine, qui était de 13,148,400 acres en 1932, a été portée à 13,528,900 acres en 1933. Par contre, l'orge qui occupait 3,757,600 acres en 1932 couvrait 3,658,000 acres cette année. Il y a eu une réduction considérable dans l'étendue en seigle; le chiffre est de 773,800 acres pour 1932 et de 583,100 acres en 1933. L'étendue en lin était également moins considérable en 1933, soit 243,600 acres, contre 453,700 acres en 1932. Il y a eu, par contre, une augmentation sensible dans l'étendue en luzerne. Quant aux autres récoltes, les changements de superficie sont peu importants.

Les rendements par acre des récoltes mentionnées ci-dessus étaient les suivants: blé 15.8 boisseaux en 1932, contre 10.5 en 1933; avoine 29.8 et 23 boisseaux, respectivement; orge 21.5 et 17.4; seigle 11.6 et 8.1; graine de lin 5.4 et 2.8; grains mélangés 33.0 et 28.4 boisseaux par acre.

La valeur des récoltes des champs était évaluée à $432,199,400 en 1931, $444,894,900 en 1932 et $427,791,000 en 1933. La valeur moyenne estimée était la suivante: blé 35c. le boisseau en 1932 et 45c. en 1933; avoine 19c. et 25c., respectivement, orge 23 et 26c., seigle 27 et 34c., graine de lin 62 et $1.12, grains mélangés 33c. et 39c. Naturellement, ces chiffres ne sont que préliminaires.

*Nombre d'animaux.*—Le Bureau fait rapport que le nombre de chevaux sur les fermes a diminué en 1933. Par contre, le nombre des bovins a augmenté, tandis que celui des moutons et des porcs diminuait. Il y a eu une très forte réduction dans le nombre de poules et de poulets, tandis que le nombre des autres espèces de volailles augmentait.

*Ventes de bestiaux.*—D'après le rapport du commerce des bestiaux du 21 décembre, le nombre de bovins vendus pendant 51 semaines de 1933 a été de 590,467 contre 563,636 pendant la même période en 1932. Le nombre de veaux vendus pendant les mêmes périodes a été de 312,522 et 298,269, respectivement, celui des moutons de 464,058 en 1933 et de 463,010 en 1932. Les porcs vendus aux parcs publics à bestiaux et directement aux salaisons se chiffraient par 3,087,582 cette année, contre 3,056,119 en 1932.

*Production du beurre.*—La Division fédérale de l'industrie laitière annonce que la production du beurre au Canada pendant les dix mois qui ont pris fin le 31 octobre, a été de 195,237,239 livres, contre 190,018,592 livres pendant la même période en 1932, soit une augmentation de 2.7 pour cent. La production a diminué dans l'Ile du Prince-Edouard, au Nouveau-Brunswick, en Colombie-Britannique et Québec, mais elle a augmenté dans les autres provinces. C'est l'Alberta qui a la plus forte augmentation, 13.3 pour cent de plus qu'en 1932, suivie par la Saskatchewan (10.4 pour cent).

*Quantité de fromage classée.*—Pendant la période allant du 28 novembre 1932 au 2 décembre 1933, il s'est classé 1,171,034 fromages contre 1,296,444 pendant la période précédente de douze mois.

*Pommes et pommes de terre.*—La Division des fruits évalue la production commerciale de pommes à 4,892,000 barils en 1933 contre 3,977,000 barils en 1932. L'étendue en pommes de terre a été évaluée à 527,700 acres en 1933 contre 521,500 acres en 1932. Le rendement a été évalué à 41,542,000 quintaux cette année, contre 39,416,000 quintaux en 1932.

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De nouveaux règlements viennent d'être établis dans la province de Québec, touchant le transport du lait et de la crème entre le producteur et le distributeur. Le transport par camions ou par véhicules à traction animale du lait ou de la crème n'est autorisé qu'entre 5 et 10 heures du matin, heure normale, entre le 1er mai et le 1er novembre. Le samedi soir, le transport du lait et de la crème aux fabriques de la campagne pourra se faire entre 5 et 9 heures, heure normale, pendant la même période. Entre le 1er novembre et le 1er mai, le transport n'est autorisé qu'entre 5 heures du matin et 1 heure de l'après-midi, et le samedi entre 5 heures du soir et 9 heures du soir.

# TENTATIVES DE CONTROLE DES VENTES PAR LES COMMISSIONS DU GOUVERNEMENT OU LES ORGANISATIONS AGISSANT AVEC L'APPUI DU GOUVERNEMENT

## PARTIE II[1]

J. COKE[2]

Nous continuerons l'exposé dans cet article du contrôle des ventes. Nous ne nous proposons pas de discuter les mérites relatifs des systèmes de contrôle ni de les comparer, au point de vue des résultats, aux méthodes habituelles de vente, mais plutôt de présenter sur les systèmes adoptés dans différents pays les renseignements que nous possédons et que nos lecteurs pourraient avoir des difficultés à se procurer ailleurs.

*Le monopole des céréales en Bulgarie.*—L'exercice d'un monopole public est devenu la règle dans certains pays, spécialement en ce qui concerne les grains panifiables et le tabac.

En décembre 1930, le gouvernement bulgare créa le Bureau central d'achat du grain, qui fut autorisé à acheter, à prix fixes, du blé et du seigle et qui commença à fonctionner en février 1931. Ce Bureau employait comme agents les coopératives, les banques et les marchands; il payait les producteurs en argent comptant et en crédits sur les taxes, ces derniers étant remboursables avant le 1er septembre 1931. C'était en somme un moyen de permettre au cultivateur de payer ses taxes, mais il causa une réduction correspondante dans le revenu de l'Etat tout en ajoutant aux charges du Trésor.[3] Au début, les paiements pour le blé ne devaient être que de vingt-cinq pour cent en argent comptant, mais ils pouvaient s'élever jusqu'à cinquante pour cent dans les achats de seigle. La proportion "comptant" fut augmentée en août 1931, et le Bureau fut autorisé à fixer des taux d emmagasinage au besoin.

Des fonds furent pourvus au moyen d'emprunts, contractés aux banques agricoles ainsi qu'à la banque coopérative. Le total des emprunts originaux se montait à $288,000. Lorsque le Bureau fut établi, il n'était autorisé qu'à acheter du blé et du seigle à des prix plus élevés que ceux qui avaient cours sur les marchés mondiaux. Ces prix devaient être arrêtés en conférence avec les représentants du gouvernement, les banques, les coopératives et les bourses à grain.[4]

Comme les prix payés par le Bureau étaient supérieurs à la cote mondiale, la quantité de grain reçue au début fut si forte qu'il se vit obligé d'abaisser ses prix. Toutefois, après quelque huit mois de fonctionnement les paiements en argent comptant dépassaient le montant des ventes, et il fut alors décidé que le gouvernement se chargerait du contrôle exclusif. Une série d'arrêtés en conseil à cet effet parut en octobre 1931. Le Bureau central d'achat du grain continua d'appliquer les règlements. Le Bureau devint ainsi l'unique acheteur ou vendeur de céréales au pays; et il fut déclaré illégal de vendre de la farine qui n'était pas faite avec du blé acheté par le Bureau ou contrôlé par le Bureau. L'industrie de la minoterie fut mise sous la surveillance directe du Bureau. Un contrôleur fut nommé pour chaque grand moulin commercial, et lorsque plusieurs petits moulins pouvaient être groupés commodément, ils étaient placés sous la direction d'un contrôleur unique. Le contrôleur a pour fonctions d'auditer les livres et de vérifier toutes les déclarations. Les salaires de ces officiers sont prélevés par le Bureau, sur les fonds fournis par les minoteries commerciales. Les moulins à pratiques sont placés sous la direction du maire de la municipalité dans laquelle ils se trouvent et auquel on doit s'adresser pour avoir un permis de mouture de blé ou de seigle.

En ce qui concerne les ventes l'enregistrement à la bourse au point de livraison pour l'exportation de toutes les ventes d'exportation, est obligatoire. Une commission de deux pour cent doit être payée à la bourse. Est obligatoire également l'enregistrement de toutes les ventes à la bourse de Sofia pour la consommation locale et les frais de commission dans ce cas sont de un pour cent; ce montant doit être redistribué parmi les bourses sur une base proportionnelle.

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[1] Voir l'Economiste agricole, Vol. III, No. 7, 8 et 9, p. 76-78.

[2] Commissaire adjoint, Division de l'économie, Ministère de l'Agriculture, Ottawa.

[3] Dolinsky, N. V. La situation agricole en Bulgarie. Rapport à la Conférence internationale des économistes agricoles, 1933. Miméographié, p. 9-10.

[4] Pour de plus amples renseignements voir Edminster, L. R., Schaben, L. J., et Lynsky, M., "F-S 56. Agricultural Price Supporting Measures In Foreign Countries. Bureau de l'économie agricole, Ministère de l'Agriculture des Etats-Unis, Washington, D.C., p. 44.

Au commencement de 1932 un cartel spécial ou une loi de monopole fut promulgué, autorisant l'Etat à dissoudre les monopoles et à fixer les prix. Des mesures ont déjà été prises en ce qui concerne le monopole du sucre. Les prix de la farine, du sucre, du sulfite de cuivre, de l'huile de tournesol et d'autres produits ont été officiellement fixés.[5]

D'autres pays et notamment la Pologne, la France, la Grèce, le Japon, et la Hongrie, ont acquis le contrôle de certaines céréales et de certains autres produits. L'Allemagne a un quasimonopole du blé.

*Le système Chadbourne du contrôle du sucre.*—Sous ce système les principaux pays exportateurs de sucre se sont entendus en mai 1931 pour restreindre les exportations de sucre. Les pays intéressés étaient les suivants: Cuba, Java, Allemagne, Tchécoslovaquie, Pologne, Hongrie et Belgique. Ces pays représentent environ quarante pour cent de la production mondiale de sucre et environ quatre-vingt-dix pour cent des exportations. Le Pérou et la Yougoslavie sont entrés plus tard dans cette convention. Le système Chadbourne ne se contente pas de fixer un contingentement pour les exportations mais il restreint la production en limitant l'étendue cultivée. Ce système est administré par un conseil permanent, appelé le Conseil international du sucre, dont les quartiers généraux sont à La Haye. L'objet était de réduire graduellement les approvisionnements de sucre.

Il était entendu que les contingents d'exportation seraient augmentés de cinq pour cent lorsque le prix f.b. du sucre cubain brut atteindrait deux cents par livre et que ce niveau serait maintenu pendant trente jours. Un nouveau relèvement des contingents d'exportation devait être effectué à mesure que les prix monteraient. Une entente intéressante fut conclue aux termes de laquelle, dans le cas où l'Allemagne n'exportait pas tout son contingent en une année quelconque, le Cuba, la Pologne, la Hongrie et la Tchécoslovaquie seraient autorisés à augmenter leurs exportations pour conbler le déficit. Des stocks de surplus dans chacun de ces pays ont été déclarés, et ces stocks doivent être réduits par portions annuelles.

Le système Chadbourne s'est heurté à quelques difficultés, provenant de la diminution dans la consommation du sucre. La production du sucre a été restreinte mais il ne paraît pas qu'il y ait eu une diminution sensible dans l'accumulation de stocks. Il lui reste encore trois ans cependant pour démontrer son efficacité. Le contingent cubain a été relevé à une réunion du Conseil en décembre 1932 à cause de la diminution des exportations sur les Etats-Unis. Le niveau des prix auxquels le premier relèvement du contingent peut être fait, a été réduit à 1.75c f.b. Cuba, sans doute à cause des cours moins élevés. Ce système a l'appui des gouvernements des pays intéressés. C'est d'ailleurs une tentative vers une unité d'action internationale qui est plus difficile à réaliser que l'unité nationale ou régionale.

*Le système Paterson de stabilisation.*—Ce système a été appliqué à la vente du beurre australien. Il fonctionne depuis le 1er janvier 1926. Il se propose trois objets:[6] (1) faire compensation pour les frais excessifs de production résultant du système fiscal de l'Australie; (2) aider à vendre le beurre de surplus; (3) stabiliser les prix du beurre en Australie. Disons ici que ce système est volontaire et qu'il est appliqué par un Comité fédéral de stabilisation, lequel se compose de représentants des intérêts laitiers coopératifs et des fabricants. Il y a également un Comité entre Etats avec Divisions d'Etat. En 1926, sous cet arrangement qui est volontaire, une taxe a été prélevée sur tout le beurre produit dans les fabriques de l'Australie, sauf dans l'état de l'Australie occidentale. Le montant de cette taxe était en premier lieu de 1d. par livre, mais il a été élevé en 1928 à 1¾d. On paie sur ce fonds une prime pour le beurre exporté. Le montant de cette prime a varié d'une année à l'autre. Il était au début de 3d. Lorsque la taxe a été élevée à 1¾d. la prime a été portée à 4d. Une année plus tard, en janvier 1929, elle a été portée à 4½d. et maintenue à ce taux jusqu'au 1er janvier 1931, lorsqu'elle fut réduite à 3½d. Trois mois plus tard, elle fut réduite à 3d., un mois plus tard à 2½d. Elle fut de nouveau relevée à 3d., en avril 1932, et elle est encore à ce chiffre.

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[5] Dolinsky, N. V. La situation agricole en Bulgarie. Rapport à la Conférence internationale des économistes agricoles, 1933, p. 11.

[6] Whitlam, A. G. Marketing Organization Annals of the Academy of Political Science, No. 158, novembre 1931, p. 114.

Les laitiers australiens prétendaient qu'ils ne pouvaient obtenir des prix domestiques supérieurs aux prix d'exportation, c'est-à-dire, les prix du monde, moins les frais de manutention, de fret, la perte en cours de transport, etc., et que leurs prix étaient inférieurs d'au moins 3d., aux "taux mondiaux". Ces trois pence sont ce que les Australiens prétendent être la différence entre leurs frais de production et la parité à Londres. On disait que ces frais étaient sensiblement augmentés par des mesures qui ont donné un marché protégé à d'autres branches de l'industrie. L'industrie laitière avait donc droit à une certaine mesure de protection.[7] Le but de la prime n'est pas tant de stimuler les exportations que de pourvoir une indemnité pour les exportateurs et de permettre ainsi une augmentation évaluée de 3d. par livre dans le prix domestique. Pour citer une opinion récente, "le résultat direct du paiement d'une prime d'exportation est que, automatiquement, sans aucun règlement, ni obligation, ni législation, le prix local, par le fonctionnement d'une loi économique, s'élève au niveau du prix d'exportation, plus la prime payée."[8]

Il est probable qu'en considérant les prétentions des champions d'un grand nombre de ces systèmes, il faudrait pour bien faire se représenter ce qui aurait pu se passer si aucun contrôle n'avait été exercé, parce que la plupart de ces systèmes ont fonctionné pendant peu de temps et que pendant ce temps il y a eu une baisse générale de prix.

Le bon fonctionnement de ce système dépend du consentement du gouvernement australien. Par exemple, peu après que ce système est entré en vigueur, il fut nécessaire de relever le tarif sur les importations de beurre. En outre, le consentement du gouvernement est essentiel parce que l'on croit que ce plan est contraire à la loi australienne contre les monopoles.[9]

Il est à noter que la production du beurre a augmenté en Australie. La production était de 273,314,000 livres en 1925-26, tandis qu'en 1931-32 elle avait atteint 390,512,000 livres. Les exportations sur le Royaume-Uni ont augmenté rapidement. Ce fait a aggravé la situation à cause du montant supplémentaire qui devait être payé aux exportateurs. Il faut reconnaître qu'il y a bien des causes différentes qui expliquent cette augmentation dans la production du beurre: les saisons favorables de paissance, les bas prix du grain, l'amélioration des pâturages, l'abandon de la culture du blé et de la production de la laine sur certaines terres pour l'adoption de l'industrie laitière. Les prix relatifs des produits agricoles étaient un autre facteur.

Outre le système Paterson il y a plusieurs Commissions de contrôle d'exportation qui fonctionnent, et notamment la Commission du contrôle des fruits desséchés, la Commission du contrôle des fruits en boîtes, la Commission du contrôle des produits laitiers, qui ont agi comme agences régulatrices sous des pouvoirs statutaires depuis 1925. Il y a en outre la législation d'état qui gouverne la vente des produits primaires et à laquelle nous ferons allusion plus tard.

Disons sous ce rapport qu'une décision récente de la Cour Suprême d'Australie frappe d'illégalité une loi de vente qui entrave la liberté du trafic entre états, laquelle est garantie par la constitution. Cette décision affecte le fonctionnement de la plupart des Commissions de contrôle. Elle implique qu'une législation fédérale et d'Etat est nécessaire et que des Commissions d'Etat peuvent être établies sous la coordination fédérale.[10] En ce qui concerne le beurre on propose que les gouvernements d'Etat adoptent une législation pourvoyant à la fixation des contingents d'exportation par la Commission de contrôle de l'Etat. Nous ne savons pas où en est cette proposition au moment où nous écrivons ces lignes, mais elle nous porte à croire que le système Paterson sera peut-être remplacé avant peu.

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[7] Brookens, P. F. Le système Paterson et les prix du beurre en Australie. Journal of Farm Economics, Vol. X, No. 4, octobre 1928, p. 540-43.

[8] Cook, A. J. Le système Paterson, Journal du Ministère de l'Agriculture pour le sud de l'Australie, Vol. XXXVI, No. 3, 15 octobre 1932, p. 323.

[9] Edminster, L. R., Schaben, L. J., et Lynsky, M., F-S 56. Agricultural Price Supporting Measures In Foreign Countries, Bureau de l'économie agricole, Washington, D.C., p. 25.

[10] Foreign Crops and Markets. Bureau de l'économie agricole, Ministère de l'Agriculture des Etats-Unis, Washington, D.C., Vol. 27, No. 1, p. 8.

# QUELQUES ASPECTS DE LA SITUATION DES TAXES DE FERME DANS L'ONTARIO[1]

S. C. HUDSON[2]

L'un des problèmes les plus graves peut-être que présente le chaos de la dépression dans lequel l'agriculture est plongée est la situation des taxes de ferme. Les cultivateurs sont incapables de payer leurs taxes; c'est à peine s'ils peuvent vivre sur leurs fermes at les arrérages de taxes se sont accumulés dans presque toutes les municipalités rurales.

TABLEAU 1.—CHIFFRES-INDICES DES TAXES DE FERME DANS L'ONTARIO 1906-1932[1] ET DES PRIX DU GROS DES PRODUITS DE FERME 1913-1932[2]
(1926 = 100)

| Année | Taxes de ferme | Prix des produits de la ferme |
|---|---|---|
| 1906 | 29.2 | — |
| 1907 | 31.4 | — |
| 1908 | 31.4 | — |
| 1909 | 32.4 | — |
| 1910 | 34.0 | — |
| 1911 | 35.8 | — |
| 1912 | 37.8 | — |
| 1913 | 42.0 | 62.6 |
| 1914 | 45.1 | 69.2 |
| 1915 | 51.2 | 77.7 |
| 1916 | 56.2 | 89.7 |
| 1917 | 63.3 | 130.0 |
| 1918 | 71.6 | 132.9 |
| 1919 | 70.7 | 145.5 |
| 1920 | 83.3 | 161.6 |
| 1921 | 88.2 | 102.8 |
| 1922 | 93.9 | 86.7 |
| 1923 | 95.3 | 79.8 |
| 1924 | 95.3 | 87.0 |
| 1925 | 97.1 | 100.4 |
| 1926 | 100.0 | 100.0 |
| 1927 | 104.6 | 102.1 |
| 1928 | 111.8 | 100.7 |
| 1929 | 114.4 | 100.8 |
| 1930 | 115.8 | 82.3 |
| 1931 | 108.0 | 56.3 |
| 1932 | 99.1 | 48.4 |

[1] Statistique municipale, province de l'Ontario.

NOTE.—Dans l'établissement du chiffre-indice qui précède des taxes de ferme pour l'Ontario, deux cantons dans chacun des 47 comtés ont été choisis. Le territoire généralement connu comme le Nord de l'Ontario et qui se compose des comtés de Cochrâne, Kenora, Nipissing, Rainy River, Sudbury, Thunder Bay et Temiskaming, ainsi que beaucoup de territoire non organisé, a été laissé en dehors de cette étude à cause des changements qui ont eu lieu dans les limites municipales au cours de cette période et aussi parce que le développement agricole dans ce territoire est encore dans la phase du pionnier. Comme les taxes de cantons comprennent les villages non incorporés, nous avons pris de préférence les cantons où la population non agricole est au minimum afin de réduire au minimum l'erreur causée par ce détail. Nous avons cherché à éviter autant que possible les cantons qui ont des utilités publiques sur lesquelles des taxes sont prélevées. Il peut se faire que les points mentionnés ci-dessus donnent lieu à quelque divergence d'opinion mais nous croyons qu'un indice établi de cette façon devrait mesurer avec un degré raisonnable d'exactitude la courbe des taxes de ferme.

[2] Prix et indices de prix, Bureau fédéral de la Statistique.

Pour bien comprendre la situation actuelle des taxes agricoles, il est nécessaire de savoir quelque chose de la progression des taxes pendant la période précédente et des rapports qui existent entre cette progression et les autres facteurs économiques. Nous avons établi dans ce but un chiffre-indice des taxes de ferme dans l'Ontario, basé sur les taxes prélevées dans quelque 94 cantons choisis, et pendant la période de

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[1] Etat préliminaire, sujet à être revisé.

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1906 à 1932. Cet indice qui est présenté au tableau 1, à côté d'un indice des prix du gros des produits de la ferme pendant la période de 1913 à 1932, montre que pendant cette période il s'est produit une augmentation très considérable des taxes de ferme dans l'Ontario, le plus haut point ayant été atteint en 1930. En 1930 les taxes de ferme étaient près de quatre fois plus élevées que celles de 1906 et près de 2.75 fois le chiffre d'avant-guerre ou de 1913. C'est entre 1915 et 1922 que la plus forte augmentation s'est produite. Il y a eu un arrêt dans le taux d'augmentation en 1919 et entre 1922 et 1926, puis une augmentation assez rapide de 1926 à 1929, et depuis ce temps une diminution marquée; l'indice de 1932 est un peu plus bas que celui de 1926. Si l'on compare l'indice des taxes de ferme avec celui du prix du gros des produits de la ferme pour la période de 1913 à 1932, on voit qu'entre 1913 et 1922 les taxes ont traîné le pas derrière les prix de la ferme et qu'elles ne constituaient pas un gros fardeau. Entre 1922 et 1924, les prix ayant baissé brusquement, les taxes sont devenues relativement plus élevées. Cette proportion relative a été modifiée quelque peu en 1925 par une hausse des prix des produits agricoles. Pendant les années 1925 à 1929 les taxes ont augmenté assez rapidement tandis que les prix restaient assez stables. L'effondrement des prix des produits agricoles, de 100.8 en 1929 à 48.4 en 1932, a été suivi par une grosse diminution des taxes en ces deux dernières années. On voit donc que lorsque les prix s'élèvent les taxes s'élèvent moins rapidement et que tant que cette courbe continue les services croissants que demande le public peuvent être payés sans difficulté, mais lorsqu'une baisse de prix se produit la demande de services se maintient et cette demande que l'on ne peut satisfaire que par des emprunts publics provoque souvent, pendant quelques années, une augmentation continue des dépenses publiques, si bien qu'il devient difficile de réduire les taxes à cause des obligations financières dont on s'est chargé les années précédentes.

Une analyse des taxes payées sur 34 fermes choisies arbitrairement dans un canton représentatif du comté de Carleton pendant la période de 1901 à 1931, à intervalles de cinq ans, nous a permis de déterminer les changements dans la répartition du dollar de la taxe du cultivateur. Cette répartition qui est présentée dans le tableau 2, indique l'acheminement qui s'est fait vers l'égalisation des dépenses municipales dans le comté.

TABLEAU 2.—DISTRIBUTION DU DOLLAR-TAXE DU CULTIVATEUR PAR PERIODE DE CINQ ANS 1901-1931

| Année | Fins du comté | Fins du canton | Fins scolaires | Total des taxes |
|---|---|---|---|---|
| 1901 | 24 6 | 31.4 | 44.0 | 100 0 |
| 1906 | 23.8 | 33.2 | 43.0 | 100.0 |
| 1911 | 22.7 | 31.6 | 45.7 | 100 0 |
| 1916 | 33 6 | 25.2 | 41.2 | 100 0 |
| 1921 | 33.2 | 35.3 | 31.6 | 100.0 |
| 1926 | 46.8 | 23.8 | 29 4 | 100 0 |
| 1931 | 57.5 | 17.8 | 24.7 | 100 0 |

On voit que de 1901 à 1911 près de 44 pour cent des taxes prélevées l'ont été pour des fins scolaires et moins de 25 pour cent pour les fins du comté; en 1916 on voit qu'une proportion croissante a été affectée au comté. Comme l'analyse des taxes de 1931 montre que plus de 57 pour cent du dollar payé en taxe par les cultivateurs vont au comté et que 18 et 25 pour cent servent aux fins du canton et des écoles respectivement, il semble qu'une analyse des déboursés et des sources de revenu du comté devrait indiquer les facteurs qui causent la majeure partie de l'augmentation des taxes.

Pour les fins d'étude des recettes et déboursés du comté, nous avons choisi les comtés unis de Stormont, Dundas et Glengarry qui sont typiques de la majeure partie de l'Ontario.

TABLEAU 3—COURBE DES DEBOURSES DES COMTES UNIS DE STORMONT, DUNDAS ET GLENGARRY, PAR PERIODES DE CINQ ANS EN TERMES DE LA PERIODE 1902-06.

| Détail des dépenses | Pourcentage des déboursés pour 1902-06 | | | | |
|---|---|---|---|---|---|
| | 1907-11 | 1912-16 | 1917-21 | 1922-26 | 1927-31 |
| Administration | 107 1 | 139 2 | 187 1 | 201 4 | 239 5 |
| Protection et administration de la justice | 98 3 | 111 6 | 124 0 | 146 7 | 211 5 |
| Education | 174 6 | 214 0 | 357 7 | 719 2 | 959 8 |
| Voirie | 108 5 | 51 4 | 1,286 4 | 1,211 9 | 902 1 |
| Assistance publique | 1,297 0 | 1,797 5 | 647 8 | ,273 1 | 3,603 6 |
| Divers* | 78 6 | 376 3 | 835 8 | 323 5 | 314 2 |
| Totaux | 140 8 | 282 6 | 1,306 2 | 1,400 9 | 1,372 8 |

*Comprend la taxe sur la terre des non-résidents, les allocations spéciales, l'intérêt, le drainage, la taxe de guerre, les propriétés du comte etc

TABLEAU 4 DISTRIBUTION DES DEPENSES DES COMTES UNIS DE STORMONT, DUNDAS ET GLENGARRY PAR PERIODES DE CINQ ANS 1902-31

| Détail des dépenses | 1902-06 | 1907 11 | 1912 16 | 1917-21 | 1922-26 | 1927 31 |
|---|---|---|---|---|---|---|
| Administration | 11 3 | 8 6 | 5 6 | 1 6 | 1 6 | 2 0 |
| Protection et administration de la justice | 19 7 | 13 7 | 7 8 | 1 9 | 2 1 | 3 0 |
| Education | 48 7 | 60 4 | 36 9 | 13 3 | 24 9 | 30 4 |
| Voirie | 7 4 | 5 7 | 1 4 | 72 8 | 63 9 | 48 5 |
| Assistance publique | 5 | 4 6 | 31 9 | 2 5 | 4 6 | 13 2 |
| Subsides spéciaux | 2 3 | 2 5 | 6 5 | 4 5 | 7 | 4 |
| Taxe de guerre | - | — | 7 8 | 1 7 | — | — |
| Divers* | 10 1 | 4 5 | 2 1 | 1 7 | 2 2 | 2 5 |
| Totaux | 100 0 | 100 0 | 100 0 | 100 0 | 100 0 | 100 0 |

*Comprend la taxe sur les terres des non-résidents, les intérêts, le drainage, les propriétés du comté, etc

Les tableaux 3 et 4 dans lesquels les déboursés des comtés unis de Stormont, Dundas et Glengarry, de 1902 à 1931, sont analysés par périodes de cinq ans, montrent l'importance relative de chaque déboursé pour chaque période. L'administration, la protection et l'administration de la justice, et l'instruction étaient les principaux comptes des déboursés, les services supplémentaires dont les comtés se sont chargés pendant les dernières périodes ont réduit les deux premiers de ces comptes à une insignifiance relative. Pendant toute la période, cependant, l'instruction est restée l'un des principaux frais et n'a été dépassée que par la construction des chemins après la période de 1917-21.

Pendant la période de 1912-16 les déboursés pour l'assistance publique, qui comprend le soin des indigents et des aliénés, et les subsides aux hôpitaux et autres institutions charitables, ont été relativement élevés à cause de la forte dépense de capital nécessitée pour l'établissement d'un asile industriel et ces chiffres peuvent induire en erreur sous ce rapport. Pendant la même période des subsides spéciaux qui comprennent des allocations pour fins patriotiques, et des taxes spéciales de guerre formaient une partie relativement considérable des déboursés totaux.

Après la guerre, en raison du progrès anormal qui s'est produit dans le domaine des transports par automobile, il y a eu une demande générale pour l'amélioration des chemins. La conséquence de cette demande se voit dans le fait que pendant la période 1917 à 1921 plus de 70 pour cent des déboursés de comté ont été pour la construction des chemins. Il y a eu une légère diminution pendant la période suivante, tandis que dans la période plus récente, les déboursés pour la construction des chemins constituaient environ 48 pour cent des déboursés totaux.

La création de nouveaux services sociaux comme l'assurance-vieillesse, les allocations aux mères et les dépenses croissantes pour les soins des indigents, causées par la situarion économique, se voient dans l'augmentation des déboursés pour l'assistance publique en ces deux dernières périodes.

Les changements dans les sources de revenu d'où proviennent les fonds pourvus pour ces déboursés supplémentaires sont indiqués au tableau 5.

TABLEAU 5.—DISTRIBUTION DES RECETTES DES COMTES UNIS DE STORMONT, DUNDAS ET GLENGARRY PAR PERIODES DE CINQ ANS 1902-31

| Source du revenu | 1902-06 | 1907-11 | 1912-16 | 1917-21 | 1922-26 | 1927-31 |
|---|---|---|---|---|---|---|
| Taux des comtés | 73.6 | 69.2 | 72.7 | 60.5 | 54.2 | 66.7 |
| Subsides du gouvernement provincial | | | | | | |
| Administration de la justice | 6.7 | 3.6 | 3.2 | .5 | .5 | .8 |
| Education | 15.0 | 23.6 | 20.2 | 10.6 | 12.8 | 12.3 |
| Voirie | — | — | — | 26.6 | 30.9 | 16.0 |
| Autres sources* | 4.7 | 3.6 | 3.9 | 1.8 | 1.6 | 4.2 |
| Totaux | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

*Comprend les permis, les amendes, les droits des bureaux d'engistrement, les taxes sur les terres des non-résidents, le fonds de jury de la cour de division, diverses remises, asiles, hôpitaux, etc.

Tandis que pendant la période de 1902-1906 près de 74 pour cent des revenus du comté venaient de la la taxe générale sur les propriétés, prélevée par les municipalités qui constituent le comté, cette proportion a diminué pendant les années suivantes, si bien qu'elle n'était plus que de 54 pour cent de 1922 à 1926. Principalement à cause de la diminution dans les subsides provinciaux pour la voirie pendant la période suivante, la proportion du revenu total contribué par les cantons a été portée à environ 67 pour cent. Cependant, les données présentées dans ce tableau indiquent un changement vers la distribution provinciale des dépenses municipales.

Il semble donc que la situation actuelle des taxes de ferme soit le résultat normal de l'effondrement des prix, venant après une période de prix élevés pendant laquelle une demande insatiable de services supplémentaires s'est développée. Il semble qu'elle soit due principalement à un niveau de prix instable ou en déflation.

# LE COUT DE LA FABRICATION DU FROMAGE DANS L'ONTARIO

J. F. Booth[1] et C. V. Parker[2]

Cet article est le premier d'une série traitant de l'aspect économique de la fabrication du fromage. Les données qu'il renferme ont été recueillies en l'automne de 1932, et s'appliquent aux opérations en 1931, de 125 fromageries de l'Ontario. Une enquête semblable, portant sur 120 fabriques de la province de Québec, a été entreprise en même temps et les résultats en seront présentés dans un autre numéro de *l'Economiste.*

Dans la conduite de cette enquête, les agents des Divisions de l'industrie laitière et de l'économie du Ministère fédéral de l'Agriculture ont coopéré avec les autorités provinciales. Dans le Québec, ces autorités étaient la Division de l'industrie animale et la Division de l'économie rurale du Ministère de l'Agriculture. dans l'Ontario, la Division de l'industrie laitière du Ministère provincial de l'Agriculture et le Service de l'économie du Collège d'Agriculture de l'Ontario.

Nous ne traitons dans cet article que des frais de fonctionnement des fabriques; d'autres phases seront passées en revue plus tard.

L'industrie fromagère de l'Ontario a de nombreux problèmes à résoudre dont le plus important peut-être, parmi tous ceux qui affectent les frais de production, est le chiffre décroissant des affaires. La première fromagerie s'est établie dans le comté d'Oxford, Ontario, en 1864. L'industrie s'est ensuite développée rapidement jusqu'au commencement du siècle actuel, puis elle a décliné graduellement depuis 1904 dans l'Ontario et, en fait, dans tout le Canada. En 1931, l'Ontario comptait 714 fabriques produisant un peu plus de 84 millions de livres de fromage. Ce chiffre représente une diminution de 36.4 pour cent sur celui de 1900, qui était de près de 132 millions de livres.

Cette diminution s'explique par la demande croissante de lait pour la consommation en nature dans les grands centres urbains, et par le développement de la fabrication d'autres produits laitiers; à ces causes il convient d'ajouter l'amélioration des moyens de transport, des chemins, des moyens de manutention, etc. L'effet net de cette combinaison de circonstances a été une concurrence croissante et un chiffre décroissant d'affaires pour les fromageries, qui ne pouvaient que malaisément se plier à ce changement de conditions et tenir tête à la concurrence que leur faisait l'emploi du lait pour d'autres usages.

Le lait destiné à la production du fromage doit être livré tous les matins; on exige qu'il soit propre et frais. Dans l'établissement des fabriques, il a donc toujours été nécessaire de tenir compte de la distance à laquelle le lait doit être transporté. Dans la première période de développement, et même encore dans la plupart des régions, ceci signifie la distance à laquelle un patron doit transporter son lait tous les matins dans un véhicule tiré par des chevaux, et c'est pourquoi la région desservie par une fabrique, spécialement dans l'est et le centre de l'Ontario, est relativement faible et la distance entre les fabriques n'est souvent que de quelques milles.

Nous espérons que cet exposé des frais de production dans les fabriques de différentes capacités sera utile à ceux qui s'intéressent à l'industrie fromagère de l'Ontario.

## FRAIS DE FABRICATION DU FROMAGE

Dans les tableaux ci-joints les frais sont présentés suivant deux modes de calcul. Nous n'avons pas tenu compte des frais du charriage du lait à la fabrique ou du fromage sortant de la fromagerie.

Dans la première méthode, les frais ont été calculés au point de vue du coût pour le patron. Ils représentent les "taux" actuellement prélevés, c'est-à-dire les taux de fabrication prélevés par les propriétaires particuliers et les déductions que font les fromageries à patrons sur le prix de vente du fromage. En outre, les frais d'organisation des patrons—salaires, papeterie et épreuves du lait—ont été ajoutés aux taux pour les fabriques appartenant à des particuliers. La méthode I traite donc des frais tels qu'ils sont connus au patron. Elle représente jusqu'à un certain point ses déboursés annuels directs.

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[1] Commissaire, Division de l'économie agricole, Ottawa.
[2] Adjoint de campagne, Division de l'économie agricole, Ottawa.

Dans le tableau 1 les fabriques sont classées suivant le nombre de tonnes de fromage qu'elles produisent, et les frais pour chaque groupe sont donnés suivant les meilleurs modes de calcul. Le coût moyen par livre pour la méthode I était de 1.94c. en 1931. Il a varié de 2.34c. pour les petites fabriques à 1.75c. pour les plus grandes.

TABLEAU 1.– COMPARAISON DES TAUX ACTUELS ET DE FRAIS TOTAUX ET DE L'EFFET DU VOLUME SUR LE COUT DE LA FABRICATION DU FROMAGE

| Capacité de la fabrique | Méthode 1. Taux comptés | | Méthode 2. Coût du fonctionnement y compris les frais totaux | | Différence entre les deux méthodes |
|---|---|---|---|---|---|
| | Nombre de fabriques | Coût par livre | Nombre de fabriques | Coût par livre | |
| (tonnes de fromage) | | | | | |
| Moins de 25 | 4 | 2 34 | 6 | 2 98 | .64 |
| 25 - 49.9 | 29 | 2 09 | 35 | 2 58 | 49 |
| 50 - 74.9 | 25 | 2 13 | 37 | 2 36 | 23 |
| 75 - 99.9 | 8 | 2 12 | 11 | 2 14 | 02 |
| 100 - 124.9 | 6 | 1 87 | 12 | 2 12 | 25 |
| 125 - 149.9 | 5 | 1 78 | 7 | 2 00 | 22 |
| 150 - 174.9 | 7 | 1 78 | 8 | 1 96 | .18 |
| 175 et plus | 6 | 1 75 | 9 | 1 22 | 07 |
| Toutes les fabriques | 90 | 1 94 | 125 | 2 16 | 22 |

Nous avons constaté, en examinant les taux computés d'après la méthode I, que tous les frais ne sont pas entièrement couverts. En général, les propriétaires de fabriques n'ont pas fait une réserve suffisante pour la dépréciation en calculant les taux de fabrication et leur part de travail a été réduite d'autant. On peut en dire autant des fabriques appartenant aux patrons; les patrons ont perdu une partie de leur capital en ne couvrant pas suffisamment la dépréciation. La pratique générale dans les fromageries est de couvrir les frais de remplacement à mesure qu'ils se produisent, mais en 1931, lorsque l'on réduisait les dépenses, beaucoup de propriétaires de fabriques ont sans doute dépensé moins que d'habitude au compte capital. Nous avons constaté que les déboursés pour couvrir la dépréciation (savoir, nouveau matériel pour fins de remplacement et reconstruction des bâtiments), ne se montaient qu'à 25 pour cent des frais estimés de dépréciation pour cette année-là. Quelques propriétaires de fabriques ont dépensé plus que d'autres et naturellement les taux de dépréciation varient dans les différentes fabriques. Cependant, pour mettre tous les établissements sur la même base et également pour prendre en considération tous les frais compris dans les opérations de la fabrique, la méthode II a été adoptée. Ces frais sont aussi présentés au tableau 1.

Pour les deux genres de fabriques à patrons et privées, les frais computés par la méthode II se classent sous trois catégories: (1) les frais de fonctionnement (laissant de côté toutes les dépenses au compte capital et les salaires du fabricant) présentés sur la même base pour les deux types de fabriques; (2) l'intérêt sur le placement, compté à 5 pour cent; là dépréciation sur les bâtiments en bois à 5 pour cent, sur les structures de brique ou de pierre à 3 pour cent de la valeur actuelle; quant au matériel la dépréciation a été calculée sur la base "des années d'emploi futur"; la valeur actuelle et les années d'emploi futur pour les principaux éléments du matériel ont été déterminées; en divisant la valeur actuelle par le nombre d'années d'emploi futur nous avons obtenu un chiffre de dépréciation pour l'année de l'enquête; (3) les salaires des fabricants ont été computés en déduisant leurs dépenses des montants qu'ils reçoivent pour la fabrication du fromage.

Revenons au tableau 1; on voit que le taux moyen par livre pour la fabrication du fromage est de 2.16c. lorsque l'on tient compte de tous les frais. Une comparaison des taux d'après les deux méthodes de calcul montre que les plus grandes fabriques couvraient tous les frais plus complètement que ne faisaient les petites. En dehors

TABLEAU 2.—COUT PAR LIVRE DE FROMAGE DES DEBOURSES PRINCIPAUX D'APRES LA CAPACITE DES FABRIQUES

| Principaux déboursés | Capacité de la fabrique — Cents par livre de fromage | | | | | | | | Toutes les fabriques |
|---|---|---|---|---|---|---|---|---|---|
| | Moins de 25 tonnes | 25 à 49 9 | 50 à 74 9 | 75 à 99 9 | 100 à 124.9 | 125 à 149.9 | 150 à 174.9 | 175 à plus | |
| Boîtes | 297 | 286 | 287 | 270 | 345 | .312 | 315 | 321 | 306 |
| Fournitures | 304 | 304 | 268 | 280 | 255 | 223 | 274 | 248 | 265 |
| Combustible | 310 | 211 | 241 | 235 | 255 | .255 | 275 | 235 | 248 |
| Taxes et assurance | 093 | 103 | 089 | 083 | 064 | 062 | 054 | 051 | .072 |
| Salaires d'organisation | 147 | 082 | 083 | 084 | 055 | 062 | 042 | 063 | .069 |
| Main-d'oeuvre louée et pension | 001 | 113 | 188 | 190 | 374 | 350 | 350 | 352 | 281 |
| Salaire du fabricant | 1 245 | 974 | 810 | 678 | 522 | 489 | 405 | 414 | 628 |
| Autres déboursés de la fabrique | 048 | 041 | 038 | 038 | 039 | 038 | 032 | 041 | 039 |
| Réparations | 073 | 088 | 083 | 086 | .127 | 073 | 060 | 077 | 080 |
| Intérêt | 187 | .180 | 167 | 157 | 137 | 148 | 148 | .086 | 144 |
| Dépréciation | 305 | 286 | 252 | 271 | 218 | 212 | .193 | 125 | 218 |
| Dépenses brutes | 3.010 | 2.665 | 2.505 | 2.374 | 2.392 | 2.223 | 2.184 | 2.055 | 2.349 |
| Crédit pour le petit lait | 030 | 088 | 143 | 229 | 271 | 224 | 219 | 231 | .194 |
| Dépenses nettes | 2 98 | 2 58 | 2 36 | 2 14 | 2 12 | 2 00 | 1 96 | 1 82 | 2 16 |
| Nombre de fabriques | 6 | 35 | 37 | 11 | 12 | 7 | 8 | 9 | 123 |

Note: Dans les frais du traitement du produit du petit lait, il a été convenu de considérer la partie des recettes reçues par le fabricant comme une charge inscrite au compte de la fabrique. Pour compenser cette charge et déterminer ainsi le coût de fabrication du fromage, la partie qui restait des recettes (c'est-à-dire la somme reçue par les patrons), a été déduite des frais totaux. Pour obtenir le coût par livre, le déboursé net ainsi obtenu a été divisé par la quantité de livres de fromage fabriqué.

TABLEAU 3.—VARIATION DANS LES FRAIS DE FABRICATION DU FROMAGE PAR LIVRE

| Frais (cents par livre) | Nombre dans la catégorie | Moyenne calculée pour chaque catégorie | Pourcentage de distribution |
|---|---|---|---|
| Moins de 1.60 | 1 | 1 59 | .8 |
| 1.60 - 1.74 | 4 | 1 65 | 3.2 |
| 1.75 - 1.99 | 19 | 1 87 | 15 2 |
| 2 00 - 2.24 | 29 | 2.13 | 23 2 |
| 2.25 - 2.49 | 34 | 2 35 | 27.2 |
| 2.50 - 2.74 | 19 | 2.61 | 15.2 |
| 2.75 - 2.99 | 11 | 2 85 | 8.8 |
| 3.00 - 3.24 | 7 | 3.11 | 5.6 |
| 3.25 et plus | 1 | 3.27 | .8 |
| Total ou moyenne | 125 | 2.16 | 100.0 |

du plus petit groupe de fabriques qui avaient un coût de 2.34c. par livre, les taux d'après la méthode I (frais actuels comptés) étaient d'environ 2⅛c. par livre pour les fabriques qui produisaient moins de 100 tonnes de fromage. Il y a une grosse diminution dans les taux de fabrication prélevés entre le groupe de 75-99.9 tonnes et le groupe de 100-124.9 tonnes. La diminution est moins forte dans le groupe suivant et à partir de ce dernier groupe les taux moyens sont restés à peu près les mêmes.

Les taux computés d'après la méthode II étaient beaucoup plus élevés que les taux réels dans les trois premiers groupes de fabriques de même capacité, mais ils étaient à peu près les mêmes pour le groupe de 75-99.9 tonnes. Par conséquent, si l'on prélève un taux de 2–2⅛c, les frais totaux ne peuvent être couverts que si la production atteint ou dépasse 75 tonnes. De même, si l'on compte 1.87 à 1.75c par livre, tous les frais ne peuvent être couverts que si l'on produit plus de 175 tonnes de fromage.

## L'EFFET DE LA QUANTITE SUR LES FRAIS DE PRODUCTION

Tout en représentant les différences de frais entre les méthodes I et II, le tableau 1 montre également l'effet de la quantité sur les frais de production. Le coût total pour les fabriques produisant moins de 25 tonnes de fromage était de 2.98c par livre. A mesure que la quantité produite augmente, le taux ou le coût par livre diminue. Dans le groupe à plus forte production, 175 tonnes et plus, le taux était de 1.82c. La diminution totale de frais a été de 1.16c par livre. Ces chiffres nous montrent que les frais de fabrication sont réglés dans une grande mesure par la quantité de fromage produite.

Les frais présentés au tableau 1, méthode II, sont donnés beaucoup plus en détail au tableau 2. Ici, nous voyons clairement l'effet de la quantité sur les différents déboursés. Le coût par livre attribuable aux boîtes, aux fournitures et au combustible, n'a pas, pour des raisons plus ou moins apparentes, diminué sensiblement en proportion de l'augmentation dans la capacité de la fabrique. Cependant, dans les plus grandes fabriques, il y a eu une diminution bien nette par livre lorsque l'on prend en considération ce que l'on appelle les frais fixes—taxes, assurance, intérêt et dépréciation. Quoique les frais de la main-d'oeuvre louée (autres que le fabricant) aient augmenté avec le volume de la production, le montant payé aux fromagers, computé sur une base par livre, a diminué rapidement à mesure que le volume de la production augmentait. On voit que les plus grandes fabriques se tiraient beaucoup mieux d'affaire en ce qui concerne le plus gros déboursé dans les frais de fabrique.

Les frais sont représentés d'une façon un peu différente au tableau 3. Ici, les fabriques sont arrangées par groupes, suivant les frais de fonctionnement, et l'on remarque que les extrêmes sont de 1.59c par livre dans une fabrique et de 3.27c dans une autre. Cette différence était due presque entièrement au fait que la fabrique à bas prix a fait un chiffre d'affaires beaucoup plus considérable. Cinquante pour cent environ des fabriques se trouvaient dans le groupe représenté par des frais variant de 2.0c à 2.50c par livre.

## RESUME ET CONCLUSIONS

Les frais de fabrication du fromage se rattachent intimement à la production. L'écart entre les fabriques où la production coûte le plus cher et celles où elle coûte le moins cher, est de 1.68c par livre, soit l'équivalent d'environ 15c par 100 livres de lait. Aux prix qui avaient cours en 1931, ceci représente une différence d'environ 20 pour cent. La différence entre les frais encourus par le groupe de fabriques produisant moins de 25 tonnes annuellement et ceux des fabriques dont la production est de 175 tonnes par année, est de 1.16c, soit environ 10c par 100 livres de lait.

On a obtenu cette grosse réduction dans les frais en tirant le meilleur parti possible de la main-d'oeuvre, de l'installation et du matériel, et comme, dans cette industrie, tous les bénéfices que l'on obtient de cette façon se réfléchissent directement dans le prix payé pour le lait, il semble qu'il soit désirable d'augmenter autant que possible le chiffre d'affaires. Le meilleur moyen de le faire dans bien des cas serait d'amalgamer les districts de fabriques et de fermer les fabriques inutiles. Ceci nécessiterait par contre de plus longs charrois par les patrons, ou, si les conditions le permettaient, l'organisation de routes à lait.

Lorsque les conditions des chemins ne permettent pas le charriage de grosses charges, comme celles qui seraient nécessaires si l'on organisait des routes à lait, et lorsque les patrons ne désirent pas charrier leur propre lait sur de plus longues distances, il faudrait obtenir une augmentation de volume en allongeant la période de fonctionnement, en augmentant le nombre de vaches par troupeau et la production par vache ou en détournant le lait qui va maintenant aux laiteries, aux beurreries ou aux condenseries.

Nous savons qu'il y a d'autres choses à considérer dans cette question de l'amalgamation des fabriques. Quoi qu'il en soit, il y a bien des cas où il serait avantageux d'agrandir le district desservi par une fabrique et les patrons agiraient sagement en étudiant soigneusement ce côté de la question

## REUNION DU COMITE CONJOINT FEDERAL-PROVINCIAL ECONOMIQUE DE L'ONTARIO

Une réunion du Comité conjoint fédéral-provincial en économie agricole pour l'Ontario a été tenue à Toronto les 27 et 28 novembre. C'était là la troisième réunion de ce Comité, qui avait été constitué en 1931 à une conférence convoquée par les Ministres de l'Agriculture des départements respectifs, pour chercher les moyens de résoudre les problèmes urgents dans lesquels se débattait l'agriculture. L'un des buts du Comité était de mettre fin au double emploi des efforts. Les différentes agences qui s'intéressent à l'économie agricole et aux domaines qui s'y rapportent ont passé en revue ce que l'on faisait et étudié les projets qui devraient être entrepris.

Les travaux de ce Comité ont encore resserré la collaboration qui existait entre les Ministères de l'Agriculture, le Bureau de la Statistique, les Universités et les Collèges qui s'intéressent à l'agriculture dans l'Ontario. Ceux qui assistaient à la dernière réunion et les organisations qu'ils représentaient étaient les suivants:

W. B. Somerset, Ontario Marketing Board, Toronto; Geo. Barr et J. A. Carroll, Ministère de l'Agriculture, Toronto; Professeurs F. C. Hart et C. W. Riley, Collège d'Agriculture de l'Ontario, E. E. Rielly, Université Western et W. R. Drummond, Université de Toronto; Dr. J. F. Booth, J. Coke, R. L. Wheeler, P. E. Light, Ministère fédéral de l'Agriculture; Dr T. W. Grindley, Bureau fédéral de la Statistique.

## L'AUSTRALIE PREPARE DE NOUVELLES METHODES DE VENTE POUR RESPECTER LES ACCORDS MONDIAUX SUR LE BLE

Un article paru récemment dans "Foreign Crops and Markets" prétend qu'aucune mesure législature ne sera nécessaire en Australie pour faire respecter l'accord international du blé. Une proclamation sera lancée, interdisant l'exportation non autorisée du grain ou de la farine. Tous les exportateurs devront se procurer un permis, et on leur accordera des contingents spécifiques d'exportation, basés sur la quantité qu'ils ont expédiée dans le passé. Les permis d'exportation seront sujets à certaines conditions. "Chaque exportateur autorisé devra entreprendre d'acheter des cultivateurs, tant qu'ils auront du blé à vendre, ou de réserver pour les cultivateurs et de faire des avances sur ces stocks, un boisseau de blé pour chaque deux boisseaux qu'il est autorisé à exporter pendant l'année allant du 1er août 1933 au 31 juillet 1934." Les exportateurs qui achètent plus qu'ils ne peuvent exporter pendant cette période seront autorisés à exporter librement l'année suivante, mais on prendra ces reliquats en considération en fixant le contingent individuel d'exportation pour 1934-35. Si les marchands n'offrent pas la parité mondiale pour tout le surplus exportable de blé, alors la Fédération australienne achètera elle-même le blé.

# NOTES

Des dispositions préliminaires tendant à l'établissement d'une échelle mondiale de prix minimums pour le blé doivent être présentées à la Commission internationale du blé le 22 janvier 1934 par le comité des ventes de cette organisation. Le Comité se bornera à indiquer quelles doivent être les différences de prix pour les différentes espèces de blé, et ce sera à la Commission à fixer les prix réels. Les délégués des grands pays producteurs de blé sont convaincus qu'une échelle minimum est nécessaire pendant deux ou trois mois pour que le blé puisse sortir de la position inférieure qu'il occupe actuellement sur les marchés du monde.

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Le Journal du Ministère de l'Agriculture, décembre 1933, fait rapport que la Chambre de vente du houblon a évalué des échantillons représentatifs de la récolte de 1933. Le marché s'est ouvert le 30 octobre et la Chambre a pu vendre des quantités considérables aux prix établis. Cependant, l'industrie de la brasserie a déposé une plainte formelle contre les opérations de la Chambre, et la question a été référée à un comité d'enquête.

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Le Bureau d'économie agricole, Washington, D.C., déclare qu'au 1er décembre "les prix de ce que l'on peut appeler les matières premières agricoles, comme les graines et le coton, se sont améliorés en ces dernières semaines. Ce sont généralement des indices sensibles, et leur mouvement ascensionnel est important. Par contre, les boeufs et les porcs, qui représentent des produits plus finis, ont baissé, et ces marchés sont dans un état extrêmement faible. La moyenne générale des prix des produits agricoles s'est légèrement relevée le mois dernier, tandis que le prix des choses que les cultivateurs achètent sont restés à peu près inchangés.

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Le Dr W. Allen, du Service d'exploitation des fermes de l'Université de la Saskatchewan, a été nommé Commissaire royal pour enquêter dans les problèmes de la vente du lait en Saskatchewan.

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La vente coopérative a été le sujet d'une longue discussion à la Conférence annuelle d'extension, qui a été tenue au Collège d'agriculture, Truro, Nouvelle-Ecosse, les 2-5 janvier 1934.

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On se prépare en Australie à autoriser par législation fédérale l'adoption d'un nouveau système de vente du beurre en remplacement du système Paterson qui fonctionne depuis plusieurs années et qui s'est montré insuffisant dans les conditions actuelles. D'ailleurs, on a décidé que la loi du contrôle des produits laitiers est ultra vires, et la nouvelle législation a pour but de surmonter les objections que présentait l'ancienne méthode de contrôle.

# RESUME DES ARTICLES PUBLIES EN ANGLAIS DANS CE NUMERO

### QUELQUES OBSERVATIONS CONCERNANT LES RECHERCHES SUR L'ELEVAGE EN GRANDE BRETAGNE. R. D. Sinclair, Université de l'Alberta, Edmonton, Alta.

L'auteur donne un aperçu de l'organisation des recherches en matière d'élevage en Grande Bretagne. Le développement des recherches dans ce champ est un développement d'après-guerre. Une grande partie du travail fondamental a été accomplie en peu de temps en raison de la flexibilité du système de recherches qui présente les caractères suivants: (1) Organisation d'Instituts de recherches dans les diverses sciences biologiques. (2) Coopération étroite entre les diverses institutions travaillant à des problèmes plus ou moins connexes.

### EFFET DES ENGRAIS CHIMIQUES SUR LE RENDEMENT ET LA COMPOSITION DES RECOLTES SUR LES SOLS FORESTIERS DE L'ALBERTA. R. E. McAllister, Université de l'Alberta, Edmonton, Alta.

L'auteur rapporte l'effet des divers engrais chimiques sur les rendements et la composition de diverses récoltes en sols forestiers podsoliques. L'emploi de légumineuses comme engrais vert a produit un accroissement de rendement du blé allant jusqu'à quatre fois le rendement des témoins. En général lorsque des accroissements importants de rendement furent obtenus au moyen d'engrais chimiques la teneur en azote et en phosphore a été réduite, sauf la teneur en azote du trèfle qui a augmenté avec le rendement. L'avoine et l'orge, qu'elles aient ou non été fertilisées, ont accusé un pourcentage de matières azotées bien au-dessous de la normale.

### INFECTION DU BLE DE PRINTEMPS PAR DES SPORES DE CARIE AYANT HIVERNE DANS LE SOL. W. F. Hanna et W. Popp, Laboratoire fédéral de recherches sur la rouille, Winnipeg, Man.

Les résultats d'essais de germination de spores de carie (*Tilletia tritici*) ayant passé l'hiver en terre en 1932–1933 ont été semblables à ceux de l'année précédente. Des spores provenant d'épis infectés de blé Mindum ayant passé l'hiver à la surface du sol ont mieux germé que les spores provenant d'épis enterrés. A l'automne 1932, des épis cariés, des grains cariés et des spores de carié passées au tamis furent appliqués sur trois parcelles. Du blé Cérès traité à la formaline fut semé sur ces parcelles au printemps 1933 et produisit un certain nombre de pieds cariés. Quelques-unes des plantes croissant spontanément sur les parcelles ayant reçu les épis et les grains cariés furent aussi infectées.

## REVUE

### RAPPORT DE LA COMMISSION ROYALE SUR LES SYSTEMES BANCAIRE ET MONETAIRE AU CANADA, 1933. J. O. Patenaude, Imprimeur du Roi, Ottawa, prix 50 cents.

Tout le problème que la Commission a été chargée d'étudier peut se résumer comme suit: Quelle est la situation économique générale au Canada? Les systèmes financiers et bancaires qui existent actuellement sont-ils suffisamment organisés pour tenir tête aux problèmes monétaires et financiers auxquels cette situation donne naissance?

Après une revue complète de la situation, la Commission à la majorité recommande "qu'une banque centrale soit immédiatement établie au Canada, et elle recommande à l'unanimité qu'une enquête soit instituée par le Gouvernement fédéral, de préférence avec la collaboration des Gouvernements provinciaux, pour étudier les organisations existantes de crédit rural en vue de préparer un système qui sera soumis au Parlement."

Dans le dernier paragraphe du chapitre sur le crédit rural, la Commission déclare que les matériaux mis à sa disposition au cours de l'enquête n'étaient pas suffisants pour permettre de faire une recommandation spécifique sur la forme précise que cette organisation pourrait prendre. Les preuves présentées ont convaincu la Commission que le besoin de cette agence est réel.

# NOTES AND NEWS

## NATIONAL ADVISORY COMMITTEE ON AGRICULTURAL SERVICES EXECUTIVE MEETINGS

In the August, 1933, issue of *Scientific Agriculture* an account was given of the Regina meeting of the National Advisory Committee on Agricultural Services. It was stated that an Executive of the National Committee had been appointed consisting of nine men who are in a position to meet at fairly frequent intervals. The function of the Executive is to review the progress of joint committees working on various problems involving the different services, and to appoint any committees where necessary.

The first meeting of the Executive was held in the office of Dr. H. Barton, Deputy Minister of Agriculture, on October 19th. There was a full attendance as follows: Dr. H. Barton, Dr. G. I. Christie, Rev. Fr. Leopold, Dr. W. J. Black, Mr. J. B. Fairbairn, Dr. E. S. Archibald, Dr. L. P. Roy, Dr. R. Newton, Mr. H. L. Trueman. Dr. L. P. Roy represented Mr. J. A. Grenier, Deputy Minister of Agriculture for Quebec. Dr. H. Barton was elected Chairman of the Executive and Mr. H. L. Trueman was elected Secretary.

A discussion took place on the relation of the Executive to the "special standing committees" which it is authorized to appoint according to the resolution adopted at the National Conference on Agricultural Services in Regina in 1933. It was agreed that these committees should be small committees assigned to regional or national problems and should be responsible directly to the Executive of the National Advisory Committee; the function of these standing committees is to co-ordinate the activities of problem committees now in existence and to arrange for the appointment of additional problem committees where needed. It was also agreed that the name of each committee should indicate as far as possible its field, and that the scope of activities of each committee should be defined by the Executive of the National Advisory Committee. It was further agreed that a survey of the personnel and activities of existing problem committees be made at once. The Executive members will then be asked to study the activities of the various committees with a view to determining what problems are most urgent.

Following the recommendation of the National Committee, small committees of three men, with power to add to their number, were appointed to deal with problems arising out of the Conference at Regina as follows:

*Barley Committee*—Prof. T. J. Harrison (Chairman), Board of Grain Commissioners for Canada, Winnipeg; Mr. L. H. Newman, Central Experimental Farm, Ottawa; and Dr. O. S. Aamodt, University of Alberta, Edmonton. The function of this committee is to bring up to date information collected by the former joint committee on barley, and to make recommendations for carrying out further co-operative projects.

*Committee on Seed Grain*—Mr. L. H. Newman (Chairman), Central Experimental Farm, Ottawa; Mr. W. T. G. Weiner, Canadian Seed Growers' Association, Ottawa, nd Dr. G. P. McRostie, University of Manitoba, Winnipeg. This committee was set up in response to a resolution sponsored by the Canadian Seed Growers' Association asking for further co-operative effort on the part of departments and commercial organizations to increase the use of better seed. The extension project in the use of better seed carried on by the Searle Grain Company and other commercial companies in co-operation with departments was placed under the direction of this committee.

*Committee on Publication of Research*—Dr. G. I. Christie (Chairman), Ontario Agricultural College, Guelph; Rev. Fr. Leopold, Oka Agricultural Institute, La Trappe, P.Q.; and Dean A. M. Shaw, University of Ssakstchewan, Saskatoon. It was suggested that Dr. E. S. Archibald, Central Experimental Farm, Ottawa, Dr. R; Newton, National Research Council, Ottawa; and Mr. H. L. Trueman, Canadian Society of Technical Agriculturists, Ottawa, be recommended as additional members. This committee was asked to survey the facilities for the publication of agricultural research and experimentation now available in Canada and to make definite recommendations or the financing of the technical journal, *Scientific Agriculture.*

The second meeting of the Executive was held on November 22nd in the office of Mr. J. B. Fairbairn, Deputy Minister of Agriculture for Ontario. There was again a full attendance of the members. Reports of activities were received from the Committee on Seed Grain and the Barley Committee.

A discussion took place on the co-ordination of research and investigational work in cold storage. It was pointed out that there is at present no committee through which various institutions and departments conducting cold storage investigations can pool their information and plan co-operative projects. It was decided that before any such committee should be appointed there should be a survey conducted of work under way, and opinions gathered as to the need and functions of such a committee This survey is now proceeding.

Acting upon recommendations from both the Toronto Conference and the Regina Conference, and from the Canadian Society of Agricultural Economics, the Executive discussed the advisability of establishing an agricultural outlook service for Canada. It was agreed that it is highly desirable to present consolidated information on the farm products marketing picture in a form readily understandable by farmers. It was intimated that this information would not by any means solve the problems of production and marketing, but that in many cases it might form the basis for wider and better co-ordinated policies for certain farm products. The following committee was appointed with power to add to their numbers:

*Agricultural Outlook Committee*—Dr. J. F. Booth (Chairman), Dominion Department of Agriculture, Ottawa; Dr. T. W. Grindley, Department of Trade and Commerce, Ottawa; and Dr. J. E. Lattimer, Macdonald College, P.Q. This committee is now functioning and an agricultural outlook statement is under preparation.

Before closing the Executive meeting in Toronto a lengthy discussion took place on the relation of agricultural services to commercial marketing facilities, and questions such as national marketing conferences and marketing legislation were thoroughly discussed.

## C.S.T.A. CONVENTION AT MACDONALD COLLEGE

At a meeting of the Board of Directors of the C.S.T.A. at Toronto during the Royal Winter Fair, it was definitely decided to accept the invitation of the Quebec Government to hold the 1934 convention in the Province of Quebec. As invitations had been received from several of the Quebec sections, it was finally decided to meet at Macdonald College and Oka Agricultural Institute and also at Quebec City. The Canadian Seed Growers' Association is planning to meet during the third week of June at Macdonald College and Oka and the C.S.T.A. expects to follow with its convention during the fourth week of June. Affiliated groups are already working on their programmes and a strong central committee and special committees have been appointed. An enthusiastic meeting was held at Macdonald College on January 18th, details o which will be given in the February issue.

## M. B. DAVIS APPOINTED DOMINION HORTICULTURIST

Mr. M. B. Davis, B.S.A., M.Sc., has been appointed Dominion Horticulturist in the Dominion Experimental Farms Branch, Dominion Department of Agriculture. This position recently became vacant on account of the passing of Dr. W. T. Macoun.

Mr. Davis has the years of service, training and experience which admirably fit him for this responsible position. He was born in Yarmouth N.S.,, and received his early education in the public and high schools of his native town, graduating from Macdonald College, (McGill) with the degree of B.S.A. in 1912.

On graduation he became manager of Sunnyside Farm, Ltd., Bridgetown, Nova Scotia. He took an active interest in co-operative marketing, becoming a director of the Bridgetown Fruit Company, and was a member of the committee of five which planned the organization of the present United Fruit Companies of Nova Scotia, Ltd. He was made the first secretary of that organization.

Mr. Davis was appointed Assistant to the Dominion Horticulturist in 1914. He served overseas with the first McGill Battery from May 1916 to December 1918. He was appointed Chief Assistant in the Division of Horticulture in 1919 on his return from overseas.

In 1922, he took post graduate work at the University of Minnesota for one quarter and in 1929-30 spent one year in England, mainly at the University of Bristol from which he received the degree of M.Sc. Mr. Davis is the author of a number of popular bulletins and scientific publications and during his tenure of office has been in charge of fruit breeding work at the Central Experimental Farm. He has also specialized in plant nutritional work with horticultural crops. His wide experience and exceptional training make him well qualified to render fine service to Canadian Horticulture.

## BOWLING TOURNAMENT

Following a custom inaugurated two or three years ago, some of the C.S.T.A. locals in Ontario and Quebec have conducted a five-pin bowling tournament. This year scores were kept during the week of December 11th. Three locals participated with the following results:

1. Average Scores for whole evening:

| | | | |
|---|---|---|---|
| Montreal City | 8 players | Average for 3 games | 182.791 |
| Toronto | 36 " | " " 2 " | 178.6 |
| Ottawa | 24 " | " " 3 " | 163.7 |

2. Average Scores on basis of 2 games:

| | | | |
|---|---|---|---|
| Montreal City | 8 players | Average for 2 games | 197.187 |
| Toronto | 36 " | " " 2 " | 178.6 |
| Ottawa | 24 " | " " 2 " | 176.2 |

3. High individual scores:

Toronto, C. H. Hodge—High Single Game ........305
C. H. Hodge—High Two Games ...........305

Ottawa, P. W. Chepeswick—High Single Game .......287
P. W. Chepeswick—High Two Games..........486

Montreal City, B. Leslie Emslie—High Single Game .....252
O. R. Evans—High Two Games ...........476

The honours for this round have gone to Montreal, without even having to count the additional decimal places so kindly furnished by their secretary in his compilations. The low individual scores were also furnished by each secretary, but to avoid possible libel suits these are not being printed in *Scientific Agriculture.* It is perhaps sufficient to mention that the record for low single and low games is held in Toronto. A second series, open to the Dominion, will be rolled during the week of February 12th.

## DOMINION CIVIL SERVICE POSITION OPEN

The Civil Service Commission of Canada announces an open competitive examination for the following position.

22956. An Assistant Chemist (Male) for the Seed Branch, Department of Agriculture, Ottawa, at an initial salary of $2,220 per annum. By legislation this salary is subject to a deduction of 10 per cent during the fiscal year beginning April 1, 1933.

*Duties.*—Under direction to perform difficult chemical analyses, on feeding stuffs, fertilizers, economic poisons and related matter, and to perform other related work as required.

*Qualifications Required.*—Graduation from a university of recognized standing with specialization in Chemistry; at least three years of laboratory experience subsequent to graduation in a commercial or similar laboratory in Analytical Chemistry; preferably some experience in the analysis of compounds of copper, lead, arsenic, sulphur, and of alkaloids and other organic compounds; accuracy and aptitude. While a definite age limit has not been fixed for this competition, age may be a determining factor when making a selection.

*Nature of Examination.*—A rating on Education and Experience will be given from the sworn statements, supporting docuents and other evidence submitted by applicants. Candidates must give full particulars regarding their technical training and experience, especially as they bear on the qualifications for and duties of this class of position. An oral examination may also be given, if necessary.

Although this competition will qualify for permanency, the appoinment will for the present be on a temporary basis and for such period, probably not exceeding six months, as the Department may require. The person selected will be eligible for re-engagement for similar work in successive seasons, and in the event of securing permanent or seasonal employment will be eligible for increases at the rate of $120 per annum until a maximum of $2,700 has been reached.

An eligible list may be established which will be valid for a period of one year. Application forms properly filled in must be filed with the Civil Service Commission, Ottawa, not later than Febrauary 1, 1934.

## NOTES AND NEWS

R. Harcourt (Toronto '93), Head of the Chemistry Department, Ontario Agricultural College, Guelph, has been elected President of the Association of Official Agricultural Chemists. This organization covers the United States and Canada and the appointment of Dr. Harcourt is a signal honour to himself and the O.A.C., particularly so in view of the fact that the Association celebrates its Fiftieth Anniversary next year and this is the first time a president has been chosen from outside the United States.

C. W. Buchanan (Toronto '11), formerly Agricultural Representative for the Thunder Bay district with headquarters at Fort William, has been transferred to Napanee as representative for the Counties of Lennox and Addington.

A. A. Toole (Toronto '12) has been appointed Agricultural Representative at Fort William, Ont.

H. M. Thompson (Alberta '33) has changed his address to Box 46, Abbotsford, B. C.

E. L. Eaton (Toronto '20), formerly Professor of Agronomy and Farm Superintendent, Nova Scotia Agricultural College, is now farming at Upper Canard, N.S.

R. Innes (McGill '11), formerly Deputy Minister of Agriculture for Nova Scotia, is now farming at Coldbrook, N.S.

W. A. Middleton (McGill '13), formerly Professor of Horticulture, Nova Scotia Agricultural College, has returned to his home in British Columbia.

A. C. Heise (Manitoba '18), formerly Dominion Seed and Feed Inspector, Dominion Seed Branch, Fort William, has changed his office address to Customs Building, North May St., Fort William, Ont.

E. Boudreau (Laval '32) is now with the Live Stock Branch of the Quebec Department of Agriculture and is located at Quebec City.

John Maxwell Armstrong (Saskatchewan '25), Cytologist, Forage Division, Central Experimental Farm, Ottawa, was married on December 28th, 1933, to Lillian Hay (B.A., Sask. '32) of Saskatoon. Dr. Armstrong has recently received his Ph.D. from McGill, and is located in Ottawa.

N. S. Golding (Toronto '14), formerly Associate Professor of Dairying, University of British Columbia, is now Associate Professor of Dairy Manufactures at the College of Agriculture, University of Idaho, Moscow, Idaho.

The sympathy of members of the C.S.T.A. is extended to Mr. L. H. Newman, Dominion Cerealist. Mr. Newman lost both his mother and his brother during the first ten days of the New Year. Both were apparently in the best of health and their death has been a great shock to members of the family. Mr. Fred Newman was with the Poultry Division of the Dominion Live Stock Branch.

## NEW MEMBERS

The following members have been received since June 1, 1933:

Rosairo Barabe (Laval 1932, B.A.), Ste Anne de la Pocatairc, P.Q.
H. D. Branion (Toronto 1928, Ph.D.), Guelph, Ont.
A. J. Cooper (Manitoba 1931, B.S.A.), Brandon, Man.
J. A. Eaket (Manitoba 1930, B.S.A.), Winnipeg, Man.
T. L. Forster (Manitoba 1933, B.S.A.), Winnipeg, Man.
Eugene Godbout (Laval 1932, B.A.), Ste. Anne de la Pocatiere, P.Q.
Gostick, Frank (England 1897, N.D.D.), Winnipeg, Man.
J. A. McGregor (Manitoba 1923, B.S.A.), Winnipeg, Man.
J. McLean (Toronto 1921, B.S.A.), Winnipeg, Man.
W. S. Nesbitt (Manitoba 1931, B.S.A.), Shoal Lake, Man.
John H. Parker (Minnesota 1913, B.S.), Manhattan, Kansas.
H. A. Purdy (Saskatchewan 1932, B.S.A.), Saskatoon, Sask.
C. E. Rich (Saskatchewan 1927, B.Sc.), Moose Jaw, Sask.
T. W. T. Smith (Saskatchewan 1932, B.S.A.), Saskatoon, Sask.
Robert Whiteman (Manitoba 1912, B.S.A.), Winnipeg, Man.
O. Winkler (Manitoba 1931, B.S.A.), Canora, Sask.

SCIENTIFIC AGRICULTURE

Vol. XIV FEBRUARY, 1934 No. 6

# THE POSITION OF AGRICULTURE IN THE ECONOMIC LIFE OF CANADA

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[Received for publication January 2, 1934]

The object of this article is to consider the relative importance of agriculture in Canada and the special problem of Canadian agriculture in depression. It has no intention of reviving the hackneyed and futile argument regarding the relative importance of agriculture and industry nor to insist on the Physiocratic notion that the land and the farmers are all-important. Industrial and agricultural endeavours are clearly inter-dependent, but the position of industry is intensively advertised and well understood, while agriculture sits quietly at home and is generally regarded as the Cinderella in the national family. As the late Sir Horace Plunkett once said: "So little thought has been given—and even now is given—to the rural side of things."

Canada has an area of about 350 million acres of land suitable for farming purposes. Of this total, 163¼ million acres are in occupied farms, of which nearly 86 million acres are improved land. Even at the low valuations existing in June, 1932, farm land was valued at $1,948,070,000. Buildings on farms represented a further investment of $1,342,924,000 at 1932 valuations. These figures indicate the extent of our investment in agriculture, an industry which supports nearly five million of our population directly, and many others indirectly through farm purchasing power.

During the present period of depression it has become even more evident that agriculture has a very important place in the determination of our economic stability. As long as farm production and prices are normal, the farmer's purchasing power is an important influence in keeping manufacturing, transportation and distribution interests in profitable operation. As the world sinks into depression, commodity prices decline. The prices of staple farm products generally begin the movement and carry it the greatest distance. The other cost items such as wages, taxes, mortgage rates, equipment prices, and transportation charges lag behind on the downward trend. Naturally, retail and wholesale prices—which include many of these costs in high proportion—decline less slowly. Thus the stimulating effects of low prices on consumption are not quickly felt, as prices to consumers do not fall at nearly the same rate nor to the same extent as producers' prices. Demand, therefore, is further affected and the decline in the prices of farm products accentuated.

The individual farmer's net income is small—his annual cash receipts are, even in good times, dangerously close to the sum of fixed charges, such as taxes and mortgage and machinery debts. That this is true is indicated by the fact that only a mere handful of farmers pay federal income tax.

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[1] Chief, Agricultural Section.

World depression soon strikes the farmer and deprives him of his surplus purchasing power to the almost immediate detriment of the country's economy. Industrial occupations are directly affected by the reduced ability of farmers to pay for consumption goods.

## FARM EXPENSES

The census of 1931 reveals the following expenditures by farmers in 1930:

| | |
|---|---|
| Labour | $100,425,980 |
| Taxes | 54,134,640 |
| Feed | 47,283,610 |
| Farm machinery | 31,522,200 |
| Fertilizer | 8,121,730 |
| Light and Power | 2,377,980 |

These expenses alone amount to about 244 million dollars and are by no means complete. The annual charges on farm mortgages are in the neighborhood of 50 million dollars, with no allowance for repayment of principal. Many other necessary expenses demand large outlays. About 25 to 30 million dollars are spent in cash for seeds. The census showed that at June 1, 1931, there were 105,269 tractors, 178,714 gasoline engines, 321,276 automobiles and 48,402 motor trucks on Canadian farms. All these machines require gasoline, oil and repairs and are in need of periodic replacement. Many farmers are carrying debts for farm machinery incurred in past years and the interest and principal involved are considerable. Expenditures for licenses of farm automobiles amount to several millions of dollars. Lumber and hardware constitute important expense items, especially in good times. Supplies such as binder twine, sacks, fruit boxes, etc., demand large outlays. The Canadian farm consumption of binder twine averages over 60 million pounds a year. Insurance is another item. The payments for consumption goods and for other services, such as medical and veterinary care, constitute very important factors in farm expenditure. Using the data of the census of agriculture and of the census of merchandising and service establishments as far as possible and estimating where necessary, it is calculated that the Canadian farm population spent 557 million dollars in 1930 for these above-mentioned items, apart from food and clothing. Food and apparel would account for at least 325 million and 75 million dollars respectively. The total estimate of 957 million dollars amounts to 75% of the gross agricultural revenue of 1930; it represents over $1300 per farm and $177 per rural inhabitant. In total, the large amount represented emphasizes the financial power of the farming population and shows how vital is the need for its maintenance on a remunerative basis in the promotion of national prosperity.

## INDUSTRIES AND OTHER INTERESTS DEPENDENT UPON AGRICULTURE

Farm production forms the basis of many of our great *manufacturing and processing industries* to an extent which is not generally appreciated. In 1931 (the last year for which complete statistics are available) 9,298 establishments were engaged in manufacturing products of farm origin. Of this number, only 327 firms were working with foreign agricultural products, principally rubber, cotton, sugar and coffee. The establishments using Canadian agricultural products (8,971) reported a capital of $676,422,157, employees numbering 123,076, salaries and wages of $123,027,130, and a gross value of products amounting to $761,077,995. They utilized materials having a cost value of $422,379,638. The principal industries in this class are slaughtering and meat packing; flour milling; butter- and cheese-making; tobacco, cigars and cigarettes; fruit and vegetable preparations; bread and other bakery products, biscuits, confectionery, chocolates, etc.; breweries; woollen clothing; and leather products.

Thus, in addition to providing practically half the domestic market for factory products, agriculture provides considerable raw material to keep factory wheels turning and to provide employment for urban workers.

The *transportation interests* also benefit considerably from the farming industry. Some indication of the importance of farm products to the railways may be gained by consideration of the number of cars of revenue freight loaded on Canadian railways. Deducting the rather large miscellaneous group (which contains much farm produce), fully 20 to 25% of the car loadings of revenue freight is made up of grain and grain products and livestock. Express companies also derive a considerable proportion of their revenue from transport of farm produce. Fresh milk, cream and poultry are commonly shipped by express. In recent years, there has been an increased use of motor trucks for the transport of livestock, fruit and other produce, and this has been a new factor in the creation of employment. The amount of grain transported down the Great Lakes during the season of open navigation is a large figure. The average clearances of grain from the Head of the Lakes during the past five seasons of navigation amount to 160 million bushels. Ocean-going vessels departing from Canadian ports also include in their cargoes a high proportion of Canadian agricultural products. Wheat alone provides an annual export of 242 million bushels on the basis of the past ten years. Wheat flour exports account for an additional 40 million bushels of our wheat.

During the depression years, the contraction in traffic is not nearly as great in farm products as it is in manufactured goods and equipment. Since freight rates suffer only small reductions, it follows that agriculture is an important factor in maintaining rail, lake and ocean-going transportation services during a period of depression. This fact was very evident during 1932.

Using the figures for revenue freight carried by Canadian railroads in 1930 and 1932, the total decrease was from 95,833,228 to 60,468,093 tons, which amounts to 35,365,135 tons or 37%. Agricultural products, however, declined only 762,586 tons (from 19,648,603 to 18,886,017 tons) or 3.9%, while 'animal products' declined 338,268 tons (from 2,513,206 to 2,174,938 tons) or 13.5%. Considering the entire decrease (35,365,135 tons) between the two years, 'agricultural' and 'animal products' accounted for only 3%, while mine products accounted for 46%, forest products 19%, and manufacturing and miscellaneous 32%.

The only increases between the two years were in farm products— wheat, oats, hogs, poultry and other packing house products.

Stated in another way, agriculture provided 23% of the total revenue freight in 1930 and nearly 35% in 1932.

The years 1930 and 1932 are fairly suitable for the comparison since the grain crops of the previous years (1929 and 1931) were similar in size while the crops of 1930 and 1932 were roughly comparable.

## PLACE OF AGRICULTURE IN EXTERNAL TRADE

Canada's export of agricultural products is a large factor in maintaining her position as the seventh largest contributor to world trade. In the calendar year 1932, Canada stood fifth in exports, ninth in imports, and seventh in total trade among the nations of the world. Nearly 32% of Canada's total foreign trade was composed of articles of farm origin in the fiscal year 1932-33. Over 46% of our total export trade in the fiscal year 1932-33 was made up of trade in products of farm origin. This percentage is higher than in the previous year but lower than in some past years because of the greater relative depreciation in agricultural prices and because of the particular impediments to trade in farm products recently instituted by European countries. Practically 15% of Canada's total import trade in 1931-32 was in products of farm origin. Comparing imports with exports, it is readily seen that, since agricultural exports relate to agricultural imports in the ratio of about 3¾ to 1, domestic agriculture has an important place in the balancing of our international indebtedness. This ratio has widened as the depression has become more severe. Our exports of agricultural products have declined in both amount and value as the depression has deepened, and lower proportions of our farm production are going into the export trade, but the decline in exports from other branches of our economic life has been relatively greater. Thus Canadian agriculture has been a decidedly strengthening factor in our foreign trade situation.

The effect of our wheat exports on foreign exchange rates is a well-known fact of which we have had a striking demonstration as recently as the fall months of 1932, when heavy sales to the United Kingdom notably strengthened the Canadian dollar in terms of the pound.

## FARM PRICES AND INCOME

As previously stated, the prices of farm products fall first and furthest during a depression. Their movement during the past 3 or 4 years has been typical in this respect. The wholesale price index of Canadian farm products has been below the general price level on a 1926 base since June, 1930. Thus the farmer's dollar has been deficient in purchasing power for the past 3½ years. The purchasing power of the farmer's dollar (measured by the relation of wholesale farm prices and the general price level) reached its low point in December, 1932. The rise from this level was fairly slow for four months but became extremely rapid during the early summer. Influenced mainly by rising grain prices, the upward movement reached a peak in July. Then there were steady declines until the October figures were back to the May level, but still 12% above the level of October, 1932. The November index showed a reasonable increase and the December index (53.3) was slightly lower and yet 25% above the level of a year previous.

The relation of wheat prices and the general price level is another interesting consideration. Using 1926 as a base, the index for No. 1 Northern Wheat fell from 87.0 in January, 1930, to 28.3 in December, 1932. It rose to 55.8 in July, 1933, and dropped again to 40.3 in December, where it is 42% above the level of December, 1932. The general index of wholesale prices (1926=100) fell only from 95.3 in January, 1930, to 69.0 in December, 1933. Thus, between the year 1926 and December, 1933, wheat prices fell 59.7 points while the general wholesale index fell 31.0 points. These figures for the major crop reveal not only a great decline in wheat prices, but a much greater decline in purchasing power.

The agricultural season of 1933 has been featured by reduced crop production and rising prices. Grain production is 32.3% lower than in 1932, while the production of the remaining principal field crops, such as potatoes, sugar beets and forage crops is reduced 9.8%. The rise in prices is considerable but is not yet sufficient to offset the lower production. The decline in total value of the principal Canadian field crops in 1933 as compared with 1932, if present price levels are maintained, will not exceed 6 or 7%.

Turning to livestock, prices received for cattle and calves are about 15% lower than in 1932 while lamb and hog prices are up at least 25%. It seems likely that the income from live stock in 1933 will not be greatly changed from that of 1932.

The dairy farmer is in a slightly worse position than in 1932. Butter production is higher but lower prices have been more than offsetting. Cheese production is down about 15% and prices are about the same as last year. Fluid milk prices are equal to or higher than the prices reigning in 1932 but the demand is slightly reduced.

The poultry producer has not improved his position but the higher prices obtained for eggs and poultry recently have been encouraging.

Despite these encouraging price advances, the gross agricultural revenue of Canada in 1933 will not be over 45% of the 1926 figure, which was $1,717,477,000. In 1932, our gross agricultural revenue was only $711,898,000, which in itself is a striking example of the severity of the farm depression.

A further comparison of the years 1926 and 1933 reveals that crop production is now lower and that the numbers of livestock on farms are practically the same as in 1926. The number of people on farms has increased slightly and the acreage tilled is about 4 or 5% higher. It seems logical to conclude, then, that the troubles which beset Canadian agriculture are not self-inflicted. They are not indigenous to agriculture, but foreign. With some exceptions, they are not resultant from supplies in excess of ordinary requirements, but from effective demand declining below its usual levels.

Excepting wheat, cattle and some dairy products, the decline in prices is not due to maladjustments in supply. The greater part of the tremendous price declines must be attributed to the demand side of the common equation rather than to an abnormal increase of marketable supplies. All farm prices have suffered drastic declines. It is true that the farmers have missed some opportunities—production of some agricultural commodities has been continued beyond the point where supplies could be profitably cleared. In other cases, new markets for specific Canadian farm products as created by trade treaties have not been sufficiently supplied.

Looking further into the cause of price change through declining effective demand, it is seen that domestic consumption has been well maintained in quantity. It has increased relatively, if not absolutely, as 90% of our farm production is now retained for domestic use compared with only 60% five years ago. This leaves foreign demand as the principal variant. The improved economic conditions of the United Kingdom and Europe during 1933 justify the hope that this situation is being corrected.

Canadian agriculture is essentially made up of farm homes. The common form of tenure is ownership, although this state is decreasing slightly at the expense of tenancy and part tenancy. Still in June, 1931, 586,299 farms or 80.4% of the 728,664 farms in Canada were owned by their operators. Another 67,942 farmers (9.3%) were part owners and part tenants. As a charge on the owned farms in June, 1931, stood mortgages to the amount of $677,564,100. The total farm mortgage debt of Canada at that time is estimated at about $726,000,000. This is not an excessive burden in normal times, but there is evident need for liquidation when farm revenues are so low and when farm products have such a small fraction of their usual purchasing power.

## AGRICULTURE IN DEPRESSION

In summarizing their recently-published volume on *Voluntary Allotment*, the authors, Mead and Ostrolenk give this terse description of the plight of American agriculture:

"Agriculture has continued its downward course until its products, still flooding in undiminished volume into saturated markets, are selling at the lowest prices in recorded history; until bankruptcy is an almost universal phenomenon; until farm wages have fallen to pre-Civil War levels; until the largest of American industries is prostrate."

While the same degree of depression has not been evident in Canadian agriculture, largely because of better conditions prior to 1929, we have the same difficulties attendant upon extremely low prices, grain surpluses, falling land values, and high mortgage debts and other fixed charges.

The deflated position of agriculture cannot be based on prices alone. Production must be considered first. Modification of the crop and livestock enterprises in our production programme has been found necessary throughout the depression and is still continuing as new immediate surpluses appear and new opportunities in other lines present tnemselves. The efficacy of this method of correction, however, can easily be over-estimated. A basic difficulty of agriculture in depression is that the amount of production cannot be controlled. When nature does not interfere, production is maintained at normal levels and prices must suffer drastically. Industry, of course, may roughly adjust its output to demand; both output and working time may be cut, and wage rates and the prices of goods maintained or reduced slowly and in less degree. This, however, is nothing more than the usual explanation of the disparity between farm and retail prices which is engendered as the world goes into depression. Urban wage rates and rents, prices of manufactured commodities, transportation rates, service charges, and middlemen's margins contract reluctantly and slowly.

Secondly, definite reductions in the farmers' out-of-pocket costs of production have been made. Undoubtedly, agricultural costs have been lowered more than industrial costs in the past two decades, and even since the commonly-used base period, 1926. Much of this cost reduction is the product of necessity—simply stated, the farmers had no money for many of the purposes previously regarded as reasonably necessary. Thus when we state that farm prices have fallen much more than retail prices since 1926, we are merely recognizing in part that farm costs have been lowered to a greater extent. Realizing that prices in the long run must be correlated with costs, we admit tacitly that previous ratios between farm and other prices (e.g. 1926 or even

1913) are not presently applicable—that a return to equivalent purchasing power is not indicated by the trend in costs in the interim. In any event, the return to relative parity between farm and retail prices will probably be slow.

It is evident that reductions in overhead costs at a given point of time are of as much benefit to the financial position of the farmer as increases in farm prices. The two vital correctives of the present farm problem are to be found in higher prices and lower overhead costs. Ordinary out-of-pocket costs have already been forced drastically downward. Since the beginning of the present depression, there has been a pronounced trend among farmers to achieve a complete subsistence from the farm. The first step in this programme is diversification of production—a definite plan to produce on the farm the foods necessary for the family, and the feed required by the farm livestock. These economies are extended by reduced expenditures for clothing and other necessities and luxuries. A great economy is made by farmers in the utilization of time. Family labour is used more completely and the farmers themselves have applied themselves more closely to the farm work. Part of this latter phase is a forced economy because there are fewer opportunities for outside employment. This greater utilization of labour has caused a marked decline in the expenditure for hired help.

The question of costs is troublesome because it is difficult to distinguish between reduction in costs and reduction in standards of living. During the decade or more previous to 1930, farmers became accustomed to more farm conveniences, higher education for their children, more "city" distractions. In some cases, such as expenses for automobiles, radios, power plants, etc., it is not possible to draw a hard and fast line between living standards and necessary expenses. Both have been cut severely. In the meantime, it will probably be found most heartening to use the 1913 rather than the higher 1926 base for price indexes. Present farm conditions are much more closely related to those of 1913. Many of the significant features of our agriculture developed during the war and post-war periods of relative prosperity, and have now been abandoned. Tractors and automobiles have given place to horse power; family work has displaced hired labour; many of these features may be regarded as retrograde, but they are logical steps in a forced economy. They all tend to make comparison with 1913 conditions more tenable.

The complete result of this economy, reduction of expenditure and reduction of costs, is that the farm business is placed in a sound position to benefit from improvement of prices. It is clear that since expenses and costs are reduced so drastically, the possibilities and extent of profits are greatly improved. It is this fact which justified hope in the internal farm situation at the depth of the depression.

Our agricultural price structure is largely dependent upon world conditions. Small surpluses exist in the majority of our agricultural commodities; our export trade would be hampered by purely domestic price increases. The four most important grain crops have exportable surpluses and seven of the remaining eleven principal field crops are definitely produced in excess of domestic consumption. Among the important animal products, seven of the nine are produced in surplus quantities. Domestic stocks will increase if our prices are not kept on a competitive basis with other countries. Higher prices as a remedy for the farm situation should come from improvement in foreign demand rather than from domestic initiative. Thus our main hope in better farm prices lies in better economic conditions in the markets of the world—it has been previously suggested that this hope is not forlorn.

A third consideration in the farm problem is that of taxes. The tax load on Canadian farm property is not nearly as burdensome as in the United States where government and county services are much more highly developed, with proportionately higher expenses. The local unit, whether the county or the municipality, still depends on the property tax for its revenue. This tax, of course, being inelastic, is particularly burdensome in times of reduced farm revenue. Arrears are inevitable and have been mounting in many districts. Tax rates per acre of farm land did not decline until 1932, and the adjustment is not nearly commensurate with the reduction in farm revenue.

Fourthly, the relation of mortgage debts to land values is a pressing problem and constitutes a great worry to the farmers themselves. The total value of Canadian farm lands has fallen approximately 40% since 1929. As farm income falls and taxes remain stationary or else increase, land values decline. The market for farm land becomes greatly restricted and, in some cases, buyers are not available at any price. The farm mortgage debt, being either stationary or increasing, forms a higher proportion of the falling land values. The farmer sees his equity, established by years of effort, decline and perhaps disappear. The resultant discouragement and despair are reasonable reactions. These, in addition, affect the farmer's estimate of prospective income, and have a further influence in reducing land values. Farm debts are the greatest problem at the root of the agricultural situation, and the purchasing power of the Canadian farm population must be restrained as long as a farmer's debts exceed the sale price of his land.

These reflections emphasize the serious position of the Canadian farm industry. They demonstrate the difficulty—the practical impossibility—of meeting debts contracted before deflation began in 1929 from an income reduced in the drastic manner shown. They stress the point that reduction of ordinary costs of production and expenses of living constitute the first method of meeting the farm depression, but that this is inadequate and must later be assisted by liquidation of debts and appreciation of prices. Restrictions on foreclosure are a valuable accompaniment to these forces. They prevent despair, eviction, and wholesale abandonment of farm lands.

It is possible, however, to over-emphasize the dangers in the present situation. The position of the farmer is subject to sudden and rapid change. Farm prices usually are the first to react upward from the depression. The various factors bringing deflation of income and values furnish their own antidotes and correctives. The very severity of the necessary downward adjustment in expenses measures the degree of saving and forecasts the benefit to arise when prices begin their inevitable increase. The rapidity of emergence from the depression depends on the reduction of costs, since rising prices will then become profitable sooner. Thus, it may be argued that the depression has brought about some beneficial changes in our economic system. The emergence from the present agricultural depression will not be as pronounced as in 1924. The expectations aroused in the first half of 1933 have been partly shattered; speculation on the prospects of inflation was mistaken for the long-awaited basic recovery. But a part of the price advance has been retained. The upward movement may be erratic but there is real evidence that it has begun.

# THE LIFE HISTORY AND PARASITISM OF *TAPHRINA DEFORMANS*

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[Received for publication December 1, 1933]

## INTRODUCTION

Although *Taphrina deformans* (Fcl.) Tul. has long been recognized as the causal agent of peach leaf curl, and adequate descriptions of its perfect stage, together with the pathological histology of the host tissues involved, have appeared, little is known of the activities of the fungus after the attacked leaves have fallen from the trees or of the time and manner of infection. The investigations which are reported upon herein were undertaken with the hope of elucidating these obscure points in the biology of the fungus. Three main lines of attack were adopted: the relations of weather conditions in the spring to the occurrence of the disease, the biological potentialities of the spores of *Taphrina deformans*, and the progress of infection as indicated by a microscopic examination of material chosen in the light of information obtained from the other two lines of attack.

## THE TIME OF INFECTION AND THE RELATION OF WEATHER CONDITIONS TO THE OCCURRENCE OF LEAF CURL IN THE NIAGARA FRUIT BELT

Peach leaf curl can usually be adequately controlled by a single application of fungicide to the dormant trees. In the Niagara fruit belt where the occurrence of the disease makes spraying essential, a lime sulphur spray is applied in March or April depending upon seasonal conditions. While the general success of this spray is beyond question, nevertheless there are seasons in which local epiphytotics of leaf curl occur. Usually these outbreaks are attributed to faulty spraying and in many instances this is doubtless the explanation, but in certain years the disease is altogether too prevalent for its presence to be explained entirely on this basis. For example, in the year 1929 leaf curl was so severe that a number of orchards were almost completely defoliated and, although in some of these the trees had not been sprayed until after the buds were open, there were others in which the spray had been applied before the buds showed any signs of activity. Moreover no correlation could be found between the dates of spray application and the degree of control obtained. Faulty spraying obviously cannot account entirely for such discrepancies and their complete explanation demands a knowledge of time and manner of infection.

Now if a series of sprays were applied to separate trees or branches throughout the early spring, the date on which the spray ceased to be effective would determine the approximate time at which infection had occurred. This information could then be correlated with the weather conditions which obtained at that time and some general conclusions with regard to the epidemiology of the disease arrived at. Moreover, such experiments should indicate whether or not the failure to control the disease in certain years is due entirely to faulty spraying. Experiments of this nature were begun in

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[1] Graduate Assistant in the Department of Botany.

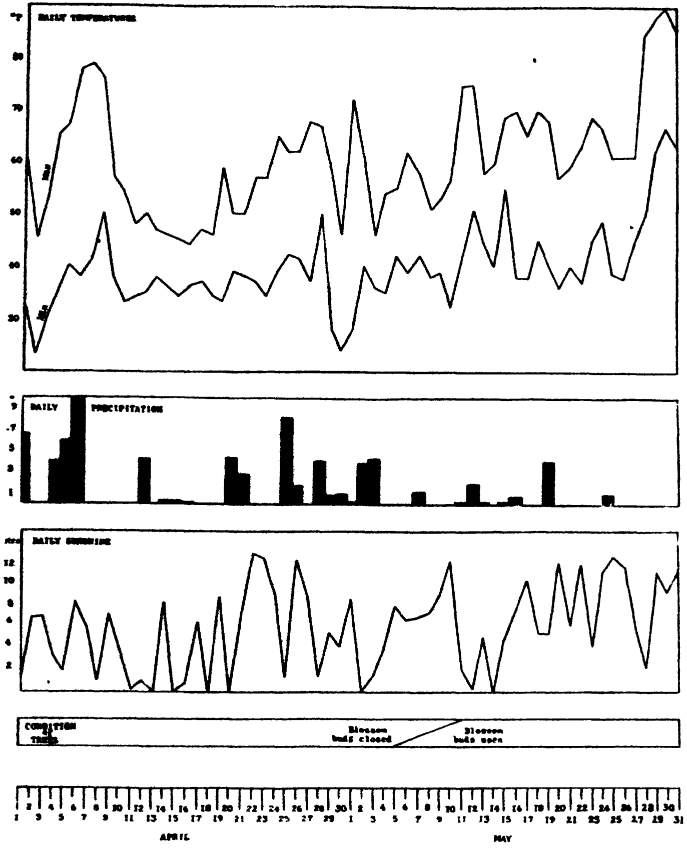

Figure 1. Summary of temperature, precipitation, sunshine, and condition of trees in the spring of 1929.

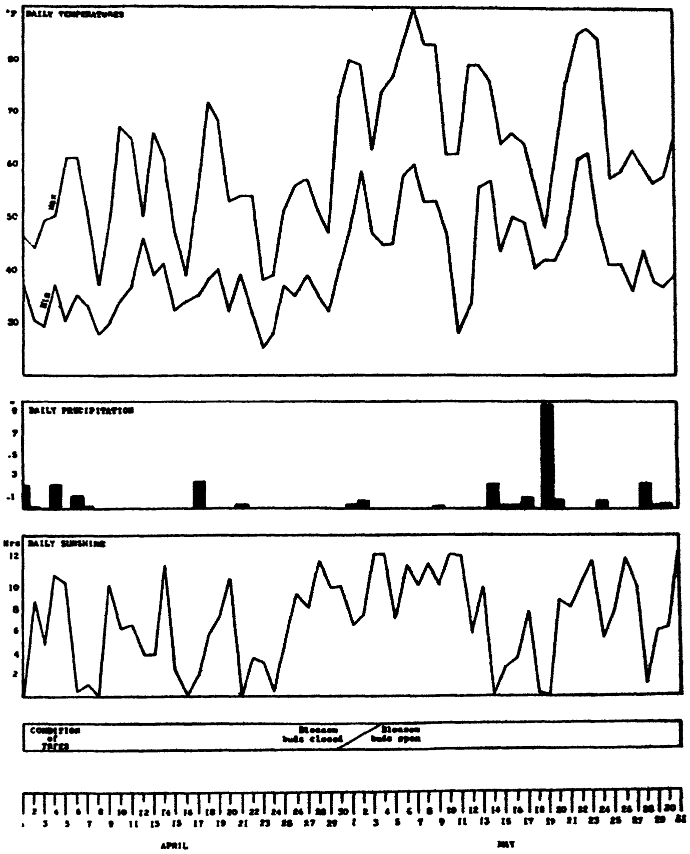

Figure 2. Summary of temperature, precipitation, sunshine, and condition of trees in the spring of 1930.

1930. Unfortunately, in contrast to 1929, the spring of which had been cold and rainy and particularly favourable to leaf curl (Figure 1), the spring of 1930 was an exceptionally dry one (Figure 2) and it was difficult to find curled leaves even in unsprayed orchards, so that no significant data were obtained from the spraying experiments of that year. The experiments made in 1931 and 1932 were more successful and these will now be described in some detail.

### Spraying Experiments in 1931

In this year a deserted orchard about two miles east of the Vineland Horticultural Experiment Station was selected. This orchard had not been sprayed in 1930 and some leaf curl had developed in it even in that unfavourable year. Selected limbs of different trees were sprayed at intervals throughout the middle and latter part of April. Four limbs were sprayed on each date so that a satisfactory distribution of the experimental material might be obtained. It was found that a little hydrated lime added to the spray mixture served to indicate how well the spray was covering. On some days high winds made it necessary to allow one application of spray to dry and then to apply a second one to ensure that every bud had been wetted.

The spring of 1931 proved a more favourable one for leaf curl than was the spring of 1930. The first signs of the disease could be readily recognized by May 18, and by June 1 ascospore discharge had commenced. Since the diseased leaves fall soon after the fungus discharges its spores, the results of the experiment were taken on June 3. These results are presented in Table 1.

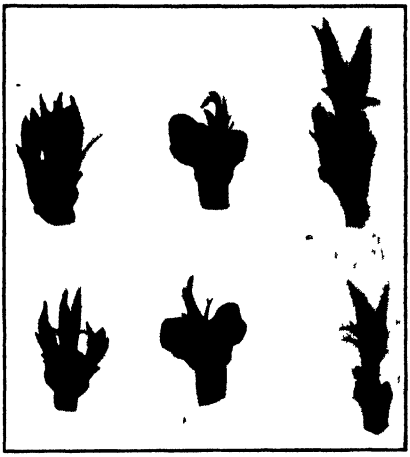

Figure 3. The stage of development on April 24, 1931—the last date on which spraying gave perfect control—of the buds in the orchard where the 1931 spraying experiments were conducted.

TABLE 1.—THE RESULTS OBTAINED FROM SPRAYING PEACH BRANCHES AT DIFFERENT DATES DURING THE SPRING OF 1931

| Date of spray application | Number of branches sprayed | Percentage of leaves curled | Percentage control |
|---|---|---|---|
| April 15 | 4 | 0 | 100 |
| " 16 | 4 | 0 | 100 |
| " 17 | 4 | 0 | 100 |
| " 18 | 4 | 0 | 100 |
| " 20 | 4 | 0 | 100 |
| " 24 | 4 | 0 | 100 |
| " 29 | 4 | 27 | 55 |
| Unsprayed checks | – | 60 | – |

From these results it is clear that no infection had occurred up to April 24. The buds at that time were well advanced and the young leaves were about half an inch long (Figure 3). Between April 24 and April 29 considerable infection must have occurred, because the spray applied on the 29th did not completely control the disease, although it markedly reduced the percentage of leaves which became infected as compared with unsprayed checks. The leaves from representative branches were removed and graded on the following basis: *healthy*—showing no curl whatever; *slightly curled*—less than one quarter of the leaf surface diseased; *moderately curled*—one quarter to three quarters of the leaf surface diseased; *completely curled*—three quarters or more of the leaf surface diseased. The results obtained from such a count of the leaves from two of the limbs sprayed on the 29th and from two unsprayed limbs are given in Table 2.

TABLE 2.—A COMPARISON OF THE LEAVES FROM TWO BRANCHES SPRAYED ON APRIL 29, 1931, AND FROM TWO UNSPRAYED BRANCHES

| Date of spray application | Total number of leaves counted | Percentage of leaves curled | | | Total percentage curled |
|---|---|---|---|---|---|
| | | Slightly | Moderately | Completely | |
| April 29, 1931 | 2331 | 8 | 7 | 12 | 27 |
| Unsprayed checks | 1526 | 14 | 14 | 32 | 60 |

The chart in Figure 4 shows the relation of these results to the conditions prevailing at the time the spray applications were made. The leaf buds in the peach orchard where the experiment was conducted began to swell about April 13 and by the 15th most of the terminal buds showed two or three millimetres of green tip. From April 10 to April 22 the days were clear with rising temperatures. On the night of April 22 the sky became cloudy and a period of cold damp weather set in. On April 29 the sky cleared but the temperature did not rise appreciably until May 2. From May 2 to May 6 the weather was fair and warm. On the night of May 6 a second period of damp cloudy weather set in. This lasted more or less intermittently until May 14 when the sky cleared and the temperature began to rise. May 15 was warm but somewhat cloudy; rain followed the next day and the temperature dropped after the rain ceased. May 17 was cool but clear. By this time the trees were well advanced and in full blossom. Leaf curl could be readily recognized on the unsprayed trees and on those limbs which were sprayed on April 29. The weather then remained fair and became warmer until May 23 when the fourth period of rain began. This lasted until the 26th, after which the sky cleared and the temperature rose to summer levels.

These experiments show that approximately half of the infection had occurred by April 29, which marks the end of the first period of wet weather. The fact that the branches which were sprayed on April 24 remained free of curl, narrows the time during which this fraction of the disease became established beyond the reach of the fungicide to four days. It is unfortunate that no branches were sprayed after April 29 so that the remainder of the infection might have been accounted for, but the buds were so far advanced by this date that further spraying would have been dangerous to the fruit and foliage.

The general experience of the peach growers in 1931 further substantiated the results of this experiment. Those who had sprayed in the early spring obtained a complete control of leaf curl and no discrepancies such as had occurred in 1929 were reported.

## SPRAYING EXPERIMENTS IN 1932

The experimental material for 1932 was limited to two trees of a group of three on the Horticultural Experiment Station at Vineland. These trees stood together on fallow land and were well isolated from other peach trees. They had been so severely attacked by leaf curl in 1931 that they were almost completely defoliated at that time. Branches of these trees were sprayed at different dates throughout the fall of 1931 and the spring of 1932. Unfortunately, owing to the limited amount of experimental material available, only one or at the most two branches could be sprayed on each date. The results obtained are presented in Table 3.

TABLE 3. THE RESULTS OF THE SPRAYING EXPERIMENTS OF 1932

| Date of spray application | Number of leaves counted | Percentage of leaves curled | | | Total percentage curled | Percentage control |
|---|---|---|---|---|---|---|
| | | Completely | Moderately | Slightly | | |
| Sept. 17, 1931 | 1989 | 18 | 19 | 24 | 61 | 36 |
| Nov. 1, 1931 | 1493 | 5 | 9 | 17 | 31 | 67 |
| Mar. 20, 1932 | 4406 | 4 | 3 | 6 | 13 | 86 |
| Apr. 7, 1932 | 4534 | 2 | 3 | 5 | 10 | 89 |
| Apr. 8, 1932 (a) | 3527 | 9 | 10 | 13 | 32 | 63 |
| Apr. 8, 1932 (b) | 2191 | 10 | 10 | 16 | 36 | |
| Apr. 11, 1932 | 2668 | 3 | 4 | 5 | 12 | 87 |
| Apr. 14, 1932 | 2212 | 2 | 1 | 3 | 6 | 94 |
| Apr. 27, 1932 | 3140 | 3 | 2 | 2 | 7 | 93 |
| May 1, 1932 | 1721 | 12 | 6 | 4 | 22 | 77 |
| May 12, 1932 (a) | 2593 | 27 | 14 | 12 | 53 | 46 |
| May 12, 1932 (b) | 2866 | 22 | 14 | 14 | 50 | |
| Check | 800 | 80 | 9 | 6 | 95 | — |

In contrast to 1931 the occurrence of leaf curl in 1932 was quite general throughout the Niagara fruit belt and many orchards which had been sprayed before the leaf buds began to open exhibited a surprisingly high incidence of the disease. Moreover, as in 1929, there seemed to be no correlation between the dates of spray application and the degree of control obtained. In the light of these general observations the results obtained from the spraying experiments prove particularly significant, for somewhat the same discrepancies are reflected in them. The unsprayed limbs which acted as checks were uniformly and severely diseased and all of the sprayed branches exhibited more or less curled leaves. Although the experimental material was decidedly limited and the size and position of the individual branches undoubtedly influenced the results obtained, yet, as can be seen from Table 3, there was a general tendency for the efficiency of the sprays to increase from September 1931 to April 1932 and then to decrease rapidly as the spring advanced. The extraordinarily heavy development of curl on the two branches sprayed on April 8 is probably due to the fact that the trees were wet with rain when

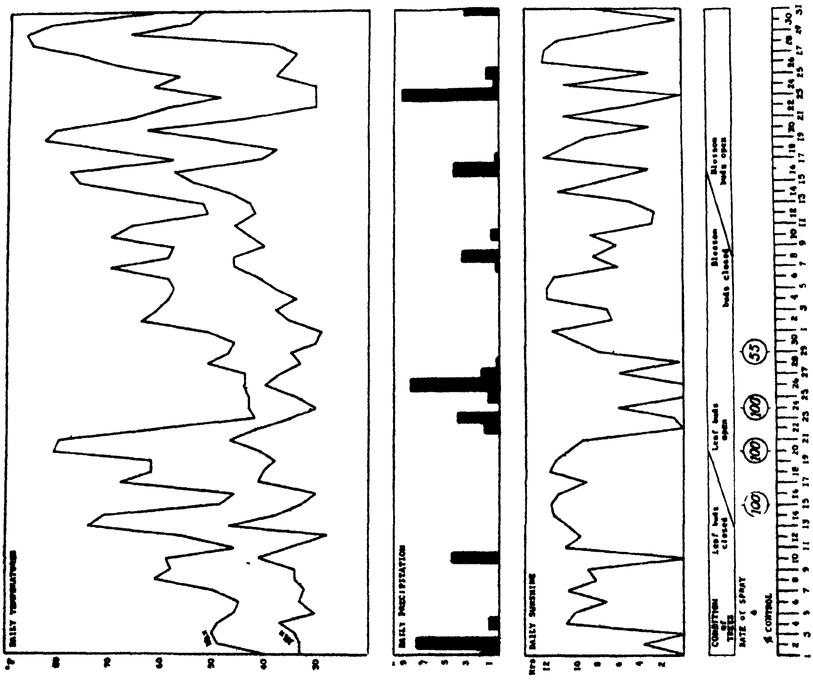

FIGURE 4. Summary of temperature, precipitation, sunshine, condition of trees, and the dates and results of the spraying experiments in 1931.

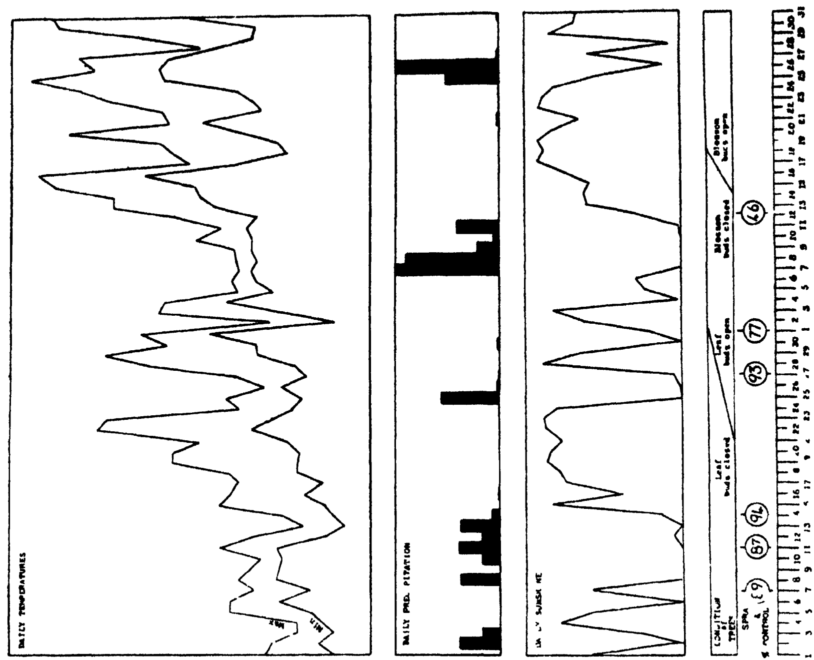

FIGURE 5. Summary of temperature, precipitation, sunshine, condition of trees, and the dates and results of spraying experiments in 1932.

the spray was applied and that it rained again soon after the application was made and before the spray had had time to dry. The results obtained from these branches are therefore not comparable with the rest of the experimental data. They are included because they show the uniformity with which the trees reacted to the sprays under a given set of conditions. This uniformity can also be seen in the results from the two sprays applied on May 12. In both cases the limbs in question were on different trees.

The chart in Figure 5 shows the relation of the results obtained from the branches which had been sprayed in April and May 1932 to the conditions prevailing that spring.

The first two weeks of April were cold and rainy but on April 15 the weather cleared and from the 17th to 23rd the days were sunny and the temperatures rising. On April 23 the temperature dropped and a period of cold damp weather set in. This lasted until April 28 and was followed by a comparatively clear warm period. On May 6 a second period of cold wet weather began. This extended until May 12 after which the sky cleared and the temperature rose.

The leaf buds began to loosen during the first period of warm weather and by April 21 the most of the terminal buds were showing green at their tips. The cool weather from April 23 to April 28 checked any further development but during the second period of warm weather from April 28 to May 6 development was rapid. The blossoms began to open about May 14 and the leaves unfolded soon after. Leaf curl could be definitely recognized on all the branches by May 16.

Although the sprays which were applied in March and April did not entirely control the disease, they reduced the percentage of curled leaves far more than did the sprays applied the previous fall. This would seem to indicate that the fungus was able to spread to the fall-sprayed branches during the winter and early spring although infection did not occur until after the buds had opened and green tissue was exposed. With the exception of the spray applied on April 8, the early spring applications were relatively efficient and controlled approximately 90% of the disease. The decrease in control on May 1 to 77% is significant and indicates that some infection had occurred during the latter part of the rainy period which extended more or less constantly from April 23 to April 28. By May 12 the efficiency of the spray had fallen to 46%, showing that by this time more than half of the infection had been successfully established and was beyond the reach of the fungicide.

It should be noted that in both 1931 and 1932 a large percentage of the disease can be accounted for only by assuming that sprays applied immediately after periods of rains can inhibit the development of the fungus in the early stages of the infection process.

## THE BIOLOGICAL POTENTIALITIES OF THE SPORES OF *Taphrina deformans*

Although in the Vineland district the ascospores of this fungus are discharged in the early summer, summer infection very rarely occurs and all evidence of the disease disappears with the dropping of the attacked leaves in June and July. Although it is an obligate parasite and cannot complete its life cycle saprophytically, the ascospores possess the potentiality of budding after the manner of the common yeasts, and cultures of these budding spores can be propagated indefinitely on artificial media. The fate of the fungus from the time the ascospores are discharged until the reappearance of the disease in the following year has never been actually determined, but all of the evidence obtained from spraying experiments indicates that perennial mycelium does not occur and that either the ascospores or their progeny are responsible for the recurrence each year of the disease. A study of the biological potentialities of these spores should throw some light on this question.

## ISOLATION AND CULTURE OF THE SPORES

The ascospores may be discharged forcibly or they may remain in the ascus and bud *in situ*. The factors which determine the mode of behaviour were not studied, but no difficulty was encountered in obtaining discharge from diseased leaf tissue with mature asci. The spores as they are discharged from the ascus cling together in a little ball and the tiny spore balls may be blown some distance without breaking up. Thus when curled leaves were fastened to the guard of an electric fan, the little packets of spores could be caught on slides some six feet away. However, these spore packets disintegrate immediately when brought into contact with a drop of water and the eight ascospores float apart from one another.

Monospore cultures were obtained in the following manner. Small pieces of curled leaves from which the asci were actively shooting their spores were attached to glass slides by vaseline. These slides were supported above sterile slides on which were placed drops of sterile water. After a number of spores had collected in each drop, the spore suspension thus obtained was streaked on the surface of plates of clear potato dextrose agar by means of a sterile loop. The plates were inverted and examined under the microscope. Single spores well separated from their neighbours were looked for and marked. When the colonies produced by the budding of these spores had attained a diameter of about half a millimetre they were picked off with a sterile platinum needle and transferred to slants of potato dextrose agar in culture tubes. In this way thirty monospore strains were obtained, each being the progeny of a single ascospore. These strains were cultured separately and they, together with a culture made by mixing the progeny of a large number of ascospores, were used in the cultural and infection experiments.

The cultural characteristics of *Taphrina deformans* growing on artificial media have been described by a number of authors (*2*, *7*, *8*). Growth is slow and appears to be favoured by the use of a soft agar medium. The colonies resemble those of a yeast. They are convex, shiny, butyrous and white in colour when young, becoming slightly pink with age. In broth culture growth is entirely sedimentary and the liquid remains clear.

The spores will bud readily in broth media of various sorts, but the heaviest growth is obtained in those media which contain some vegetable extract, such as potato extract, as a base. The function of the potato extract appears to be entirely a nutritive one for it was found that the ultimate growth as estimated by the degree of turbidity of the broth varied in direct proportion to the concentration of potato extract used. It is interesting to note that growth sufficient to produce a slight turbidity occurred even in a solution containing as low a concentration of potato extract as .008% in distilled water.

The temperature relations of *Taphrina deformans* in culture have been investigated by Mix (*8*) who found that the optimum temperature for growth on potato dextrose agar was just below 20° C., the minimum below 10° C., and the maximum somewhere between 26° and 30° C. While Mix's work was not checked in detail, his findings were in every respect substantiated during the routine of culturing the organism.

In actively growing cultures the conidia are slightly oval in shape and vary from 2.5-6µ x 4-8µ in size. Budding occurs as in yeast cells by the outgrowth of a daughter cell from one end of the parent cell. Often a second daughter cell begins to form before the first one is set free (Figure 6). In old cultures where budding is less frequent, the cells are more varied in appearance and atypical forms frequently occur. Of these atypical cells the most striking are those which possess thick walls (Figure 6, 6-11) and it has been suggested that these are resting cells which play the important rôle of tiding the fungus over unfavourable periods. Mix (*9*) believes these so-called resting cells are ascogenous cells and that the diploid stage can occur saprophytically.

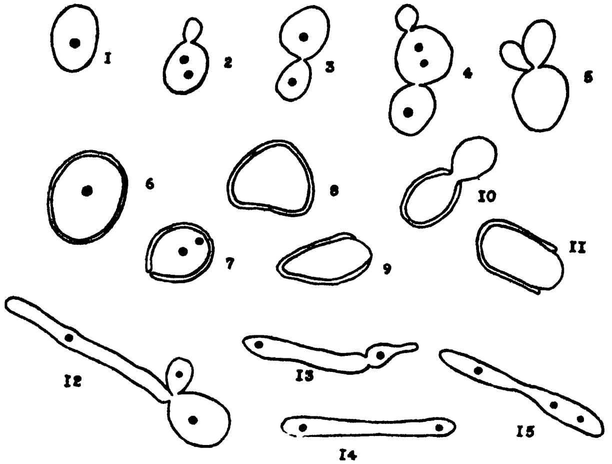

FIGURE 6. Sprout conidia of *Taphrina deformans* from monospore cultures. 1-5 Typical cells from an actively growing culture. 6-11 Atypical cells of the thick walled type from an old culture. 12-15 Atypical cells producing various forms of hypha-like outgrowths x 1400.

A true mycelium is never formed in culture but occasionally cells are found which, instead of producing typical sprout conidia, have given rise to very elongated outgrowths resembling germ tubes (Figure 6, 12-15). Wieben (*10*) and Mix (*9*) have both claimed that these germ tubes are initiated as a result of the copulation of sprout conidia in a manner comparable to that occurring in a number of smut fungi. Wieben has studied the copulation process in *Taphrina epiphylla* Sadeb. and T. *Klebahni* Wieben where she finds that two sprout conidia of opposite potentiality come to lie close together and on the side of one cell a fine papilla-like outgrowth is formed which fuses to the side of the other cell. The contents of the first cell pass through this connecting bridge and enter the other cell which immediately germinates to produce the so-called germ tube. In *T. epiphylla* and *T. Klebahni* these germ tubes are very long and are septate, whereas the atypical elongated cells found in cultures of *T. deformans* seldom exceed three to four diameters of the parent cell in length and are never septate (Figure 6, 12-15). Furthermore they were found quite as frequently in the single ascospore cultures as they were in mixed cultures, a fact which at once precludes a copulation of genetically different spores being responsible for their origin.

## THE LONGEVITY OF THE SPROUT CONIDIA

It is quite evident that if the spores are responsible for the reappearance of the disease each spring they must be able to withstand desiccation and remain viable throughout the temperature extremes of summer and winter. Viability tests made by Mix (*8*) have shown that the sprout conidia when dried upon glass cover slips are capable of remaining alive for 140 days at 30° C. and 315 days at lower temperatures. In order to test the viability of the sprout conidia still further a somewhat different procedure was adopted. This consisted essentially of inoculating sterilized soil with a suspension of sprout conidia and re-isolating the organism as required. Small flasks were used for the soil and re-isolations made by transferring samples to potato dextrose broth with a sterilized loop. All results were checked by microscopic examination.

In order to determine whether or not the viability of the thick-walled atypical cells was greater than that of the actively budding conidia, suspensions from both young and old cultures were used. The young cultures were obtained by repeated transfer to soft potato dextrose agar set in a thick layer on the bottom of a 250 cc. flask. The transfers were made by washing the spores with sterile water and using a few drops of the suspension so obtained as inoculum for other similar flasks. In this way very uniform cultures which showed no atypical cells could be maintained. Old cultures displaying a large percentage of atypical cells were easily obtained in a few weeks by placing the flask cultures in a warm room. It may be noted here that cultures kept in the refrigerator formed atypical cells much more slowly than did cultures kept at room temperature, whereas those placed in the incubator at 28° C. produced a variety of involution forms in a short time. The cultures kept in the refrigerator remained viable for months, those at room temperature tended to die out after about six weeks, while those in the incubator were dead at the end of two weeks. For this reason, in all experiments involving the use of old cultures, the viability of the culture used was tested by transfer to an agar slant at the time the experiment was set up.

On December 14, 1930, a series of flasks, each containing 50 grams of sterilized soil was inoculated with a spore suspension from an old culture. Some of the flasks were placed out-of-doors and the remainder kept at room temperature. On January 25, 1931, a similar series was inoculated with a young culture. Transfers made to potato dextrose broth throughout the winter and summer of 1931 produced growth in all cases. Since the soil in the flasks became quite dry and powdery in a few weeks the sprout conidia must have been quite inactive throughout the greater part of the experiment. The experiment was continued until July 3, 1932, by which date the number of successful transfers was beginning to fall off, indicating that most of the sprout conidia were dead. However, even at this date some of the cells were still alive, for seventeen out of thirty transfers were successful. In the case of the old cultures this was a survival of one year six and one-half months, and in that of the young culture a survival of one year five and one-half months. Thus there was virtually no difference between the longevity of the atypical cells and that of the thin-walled conidia, and under natural conditions either type of cell could be responsible for carrying the fungus through the unfavourable periods of the year.

## ISOLATION OF *Taphrina deformans* FROM DORMANT PEACH BUDS

If the recurrence of leaf curl every spring is to be attributed to spores lodged on the surface of the peach buds, it should be possible to isolate the organism from these during the winter months. To determine whether such isolations were possible, preliminary experiments were made using artificially inoculated material. A dormant peach seedling was inoculated by painting on the buds a water suspension of a young culture. The inoculation was made in January 1932 and the tree was left out-of-doors throughout the experiment. A week later one of the inoculated buds was removed and crushed in sterile water, loopfuls of which were streaked on plates of potato dextrose agar. In twenty-four hours colonies of *Dematium pullulans*, a fungus commonly associated with the bud scales of the peach, made their appearance. Young colonies of this organism are deceptively like those of *T. deformans* but this similarity quickly disappears as the colonies grow older. Two days later colonies of *T. deformans* could be recognized under the microscope and no difficulty was experienced in making transfers of these to potato dextrose slants. In February, March and April similar isolations were made from this tree and this is further evidence that the sprout conidia can withstand the rigors of winter while lodged on the surface of the peach buds.

Encouraged by the results of this experiment isolations were attempted from trees which were known to have been heavily attacked by leaf curl in the spring of 1931 and which had not been sprayed subsequently. Twenty plates of potato dextrose agar were streaked with the washings from buds of these trees and parallel plates were streaked from those of artificially inoculated ones. *T. deformans* was isolated from three of the plates streaked from the uninoculated material and from all of the plates streaked from the inoculated. This is strong evidence that spores lodged on the surface of the trees are responsible for the persistence of leaf curl from season to season.

## INFECTION CAPABILITIES OF THE SPROUT CONIDIA

Successful inoculation of peach buds with cultures of *Taphrina deformans* has been reported by both Mix (*8*) and Wieben (*10*). Mix made his inoculations in the spring before the leaf buds had opened while Wieben made hers in the summer previous to that in which the disease appeared. Although Wieben has made the suggestion that a copulation between spores of opposite potentiality takes place before infection occurs, she offers no evidence in support of this in the description of her inoculation experiments. Nor do Mix's experiments afford any evidence of the correctness of such a hypothesis since his inoculations were made with a culture derived from the eight spores of a single ascus and not from a single ascospore culture. It seemed highly desirable to determine whether such a copulation is necessary before infection can occur not only because of its fundamental significance but also because if it really were essential this might readily account in part for the marked differences in the seasonal development of the disease.

Obviously if such a copulation is a prerequisite to infection monospore cultures cannot produce the disease. In order to test the validity of such assumptions inoculation experiments were made using monospore cultures as contrasted with mixed cultures. In the fall of 1930 two well isolated peach trees which had been free of curl that summer were selected. On one tree the buds of certain branches were inoculated with a water suspension of sprout conidia from a culture made from a mixture of ascospores; on the other tree similar inoculations were made using monospore cultures on the individual branches. Check branches were left uninoculated in each case. In the spring of 1931 the inoculated branches on both trees became heavily infected with leaf curl but unfortunately the check branches also showed some diseased leaves. A similar experiment was again attempted in 1932. In this experiment a row of some thirty small trees was used. In September alternate trees on one half of the row were inoculated with a mixed culture and alternate trees on the other half inoculated individually with monospore cultures. The trees between the inoculated ones were left as checks. When leaf curl appeared in the spring of 1932, the entire row of trees was so heavily diseased that it was impossible to draw any conclusion from the experiment.

Since attempts to obtain satisfactory results from trees allowed to remain under natural conditions always seemed to be frustrated by the spread of the spores from the inoculated material to the uninoculated checks, it was evident that little progress would be made until some satisfactory method of obtaining infection under controlled conditions was devised. Accordingly a moist chamber large enough to accommodate potted peach trees was built. This chamber consisted of a rectangular framework of iron piping, the sides of which were covered with canvas and the top roofed with glass. Holes were bored at intervals in the upper part of the frame so that, by connecting this to the water supply, the canvas sides could be kept constantly wetted. In the centre of the roof a ventilator made of six-inch stove pipe was inserted and, in order to maintain the humidity of the chamber at saturation, a fine spray of water was directed into this opening. The nozzle used for obtaining this spray was one originally designed to vaporize oil for a small house-heating unit. This nozzle proved quite satisfactory and gave no trouble throughout the three months during which the moist chamber was being used.

On March 23, 1933, a number of small trees which had been potted in eight-inch pots were brought indoors and placed in a cool greenhouse. Some of the trees were inoculated immediately with a monoascospore culture and others were left uninoculated to act as checks. On April 9, by which time the leaf buds were at approximately the same stage of development as had been those of the trees used for the spraying experiments on May 1, 1932, six inocu'ated and two uninoculated trees were placed in the moist chamber where they remained until April 13. The temperature in the moist chamber during the four days elapsing between April 9 and April 13 was between 40 and 50° F. with a mean of 44° F.; the humidity remained at saturation throughout. On April 28, two weeks after the trees had been removed from the moist chamber, leaf curl was definitely recognizable on the inoculated plants and later the asci formed and ascospore discharge occurred in the normal manner. The uninoculated trees remained healthy.

This experiment proves beyond doubt that single ascospore cultures are capable of producing leaf curl, a fact which at once eliminates copulation of spores of opposite potentiality from being a prerequisite to infection.

## THE PROGRESS OF INFECTION IN *Taphrina deformans*

### MATERIALS AND METHODS

Naturally infected host material of the Elberta variety was used throughout this phase of the work. That intended to illustrate the phases of penetration and the earlier stages of infection had to be chosen especially carefully because when the leaves can first be recognized as diseased the fungus has already developed considerable mycelium within them and is beginning to bring about the characteristic hypertrophy of the cells. It is impossible to trace infection to its source in such material or to find infection hyphae with spores still attached to them. It was necessary therefore to collect material before any signs of the disease had appeared.

At short intervals throughout the spring of 1932 young leaves from the unsprayed limbs of the trees which were being used for the spray experiments were cut off and fixed in formalin-acetic-alcohol. The branches from which these leaves were taken became heavily infected and the spraying experiments showed that a large part of this infection occurred sometime about May 12. Accordingly the material which was collected on that date was examined. The leaves in this sample were from one to two centimetres in length and the blade was still folded at the midrib. Two methods of examination were employed. The first consisted in clearing the leaf so that the extent of mycelial growth could be seen in its entirety. This was done by first cutting away the midrib and separating the halves of the blade, then boiling these in lactophenol with either cotton blue or acid fuchsin until the leaves were cleared and the fungus was well differentiated.

The second method was to examine serial sections of young leaves The leaves were dehydrated by the ethyl butyl alcohol method of Zirkle (*11*) and embedded in paraffin. The sections were cut at 3-5μ and were stained with iron alum haematoxylin or Flemming's triple stain.

## PENETRATION AND SUBSEQUENT DEVELOPMENT OF THE FUNGUS

At the time infection is occurring the host tissue is still meristematic. The palisade layer has not been differentiated and the leaf parenchyma cells are closely compacted together with little or no intercellular spaces between them; some are still dividing. Stomata in all stages of development can be observed on the lower epidermis, the cells of which are elongated vertically and rich in cytoplasm. A few long unicellular hairs occur as out-growths from these cells. The upper epidermal cells are much larger and more vacuolate than are either the leaf parenchyma or the lower epidermal cells. No stomata occur on the upper surface of the leaf.

A number of spores of various kinds lodge on the outer surface of the closed leaf and in the grooves between the halves of the leaf blade. Many of these spores are sprout conidia of *T. deformans* which have not begun to infect, but are still budding upon the leaf surface. They vary somewhat in size but average 3-5μ at their greatest diameter. No large thick-walled spores such as occur in old cultures were observed.

No copulation between spores such as Wieben has described for *T. epiphylla* and *T. Klebahni* occurs prior to infection. When penetration is about to take place, the spores fasten themselves to the leaf surface by means of a short infection thread (Plate I, Figures 1 and 2) which grows out from the end of the spore at the position usually occupied by the daughter bud. As this infection thread presses against the thin cuticle of the leaf a thickening of the cuticle at the point of contact takes place. The contents of the spore pass into the thickened cuticle and the spore collapses. The fungus makes a limited amount of growth within the cuticle (Figure 7 and Plate I, Figures 3, 4 and 5). Penetration may occur on either surface of the leaf.

Figure 1 of Plate II is a photograph of the surface of an infected leaf at this stage. The leaf was cleared in lactophenol to which a few crystals of acid fuchsin had been added. A number of separate infections may be seen. The host cells and the fungus mycelia have not stained but the cuticle in which the fungus is growing has retained the stain to some extent thereby causing the individual infections to stand out in clear relief.

The intracuticular growth is very limited and the fungus soon begins to penetrate into the leaf tissue. This it does by sending down a slender hypha which forces its way between the epidermal cells until it reaches the less compacted parenchymatous tissue beneath the epidermis. Here the hypha branches out and ramifies in all directions, filling what intercellular space there is between the parenchyma cells until these appear to be enclosed in a veritable network of mycelium. Figure 2 of Plate II shows the fungus spreading through the leaf tissue from several points of infection. It will be noted that the direction of spread bears no relation to the leaf veins and that the mycelium passes over these quite readily. At this stage the mycelium is extremely fine and no septa have been formed (Plate II, Figure 3).

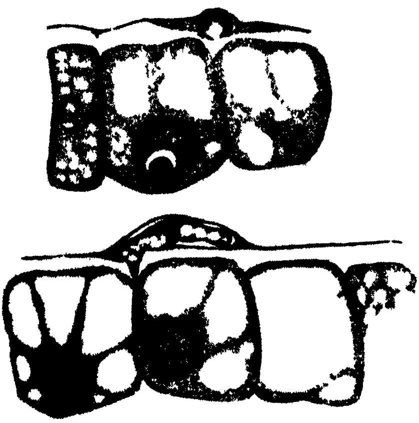

FIGURE 7. The intracuticular development of *T. deformans*.

This picture of the initial stages of the infection process in *T. deformans* which has been obtained from naturally infected material is an entirely different one from that presented by Martin (7) who claims to have found stomatal penetration both with *T. deformans* and *T. coerulescens* on artificially inoculated leaves of the Elberta peach and the bur oak respectively. Martin describes the infecting hyphae as branching dichotomously and having clear septa between the cells. In no instance has stomatal penetration been found in any of the material collected at Vineland, nor have the young hyphae shown any signs of septation during the early stages of mycelial development within the leaf.

In the early stages of infection the fungus does not appear to have any effect upon the host cells but, as soon as the mycelium has penetrated from the cuticle into the parenchyma and established itself there, the cells around the point of infection begin to increase in size. As the host cells enlarge the cuticle above the area of infection is stretched and the intracuticular mycelium collapses and dies leaving only a dark-staining area to indicate its position.

Meanwhile the leaf is maturing rapidly and there comes a stage at which the fungus no longer encroaches upon healthy tissue but remains strictly localized in the already invaded regions. Here the host cells increase in size, lose their chlorophyll, and often accumulate a red pigment in their enlarged vacuoles. Only those cells which are in actual contact with the mycelium appear to be affected and this causes the diseased tissue to appear sharply delimited from the healthy.

The mycelium now begins to increase in thickness. The hyphal walls can be readily seen in material which has been cleared in lactophenol and cross septa are laid down dividing the irregular strands into fantastically shaped cells (Plate II Figure 4). Soon hyphal branches make their way up between the epidermal cells to form a network of short thick cells beneath the cuticle. The asci are formed by the upward elongations of these cells which, as they grow, push through the cuticle forming a more or less continuous layer over the diseased area. The formation and discharge of the ascospores follows immediately, after which the leaves soon drop from the tree.

### THE NUCLEAR SITUATION

In 1894 Dangeard (*3*) demonstrated that the ascongenous cells of *Taphrina deformans* are at first binucleate, but, as the ascus is formed, the two nuclei fuse to give a single large diploid nucleus which by reduction division produces eight haploid nuclei, around which the ascospores are cut out. Moreover, the binucleate condition found in the young ascogenous cells extends back into the vegetative hyphae where each cell exhibits one or more pairs of nuclei. When and where this binucleate condition arises has remained an open question. Eftimu and Dangeard have claimed that at the time of infection the single nucleus of the spore divides to produce two nuclei, both of which pass into a germ tube, thus initiating the binucleate condition in the infecting hypha. Wieben and Mix, on the other hand, claim that it arises through the copulation of two spores, the nucleus of one spore passing into the other and this they claim, may take place in culture.

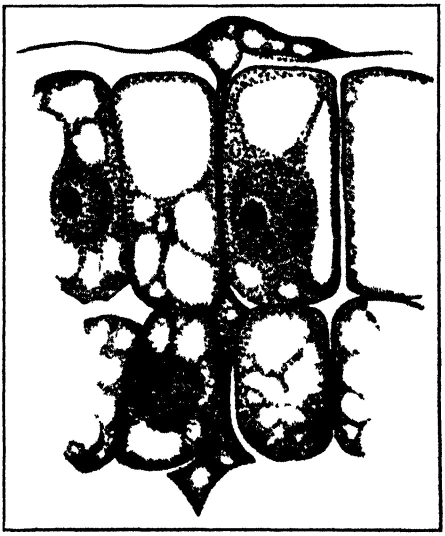

FIGURE 8. Cross section showing the binucleate condition in the intracuticular and initial intercellular mycelium.

The nuclear situation in the budding conidia from cultures was invertigated in the following manner. The spores were placed in a drop of formalin-acetic-alcohol on a flamed slide and the drop allowed to dry at room temperature. The slide was then washed for half an hour with distilled water and stained in the usual way with iron-alum haematoxylin. In young cultures the cells are for the most part uninucleate but some, which are budding, show two nuclei, one of which would have passed into the daughter cell (Figure 6, 1-4). As the culture becomes older and growth is retarded more of these binucleate cells appear. The long hypha-like cells found in old cultures usually possess more than one nucleus but the arrangement of these nuclei in no way suggests a true dicaryon condition since they often occur at opposite ends of extremely long cells (Figure 6, 12-15). Sprout conidia derived from mixed cultures exhibit precisely the same variations in nuclear condition as do those derived from single ascospores. Since in the monospore cultures all of the cells are the progeny of a single ascospore the presence of two nuclei in some of the cells cannot be due to copulation between genetically different spores as has been postulated by Mix (*9*).

The spores found on the surface of leaves exhibit the same nuclear phenomena as do those which have been grown on artificial media. For the most part they are uninucleate although a few have been observed with two nuclei. In the limited number of instances where the nuclear details could be observed at the time of penetration the nucleus appeared to have divided prior to the passage of the spore contents into the cuticle. The intracuticular mycelium always possesses at least one pair of closely associated nuclei (Figure 7 and Plate I, Figures 3, 4 and 5). As the fungus grows down between the epidermal cells to establish itself in the parenchyma tissue below, these two nuclei divide, giving rise to other pairs. Thus the binucleate condition of the mycelium is established at the outset of parasitic relationship (Figure 8).

## DISCUSSION

Originally *Taphrina deformans* was thought to be perennial in infected buds and although the advent of spraying has shown that this can hardly be so, since a single spray applied in the spring before the buds have opened will control the disease, no description of the progress of infection has hitherto been presented, nor has the form in which the fungus passes the winter been determined. The results of this investigation have supplied much of this information and we can now present an adequate description of its life cycle.

The ascospores which are discharged in the early summer, or the sprout conidia derived from them, lodge on the surface of the trees during the summer, fall, and winter but do not cause infection until the following spring, at which time, if they are washed to the opening leaf buds, and conditions of moisture and temperature are suitable, the young leaves become infected. The infecting spore produces a short peg-like hypha which attaches itself to the surface of the young leaf. The contents of the spore pass through this infection hypha into the cuticle where a limited growth occurs before further penetration takes place. From the cuticle the fungus makes its way between the epidermal cells and spreads out in the closely packed parenchymatous tissue below. The host cells in contact with the hyphae are stimulated and enlarge enormously so that the invaded area is more or less uniformly hypertrophied with the cells so closely packed that no intercellular space, other than that occupied by the fungus, remains.

It is doubtful whether the fungus ever spreads from a single point of infection to invade the entire leaf. In all of the material examined in which the entire leaf was infected there had obviously been several points of entry and, more often than not, these appeared in groups at different places on the surface of the leaf. The precise point in the ontogeny of the leaf at which the fungus within the leaf ceases to invade healthy tissue was not determined but it occurs at some time during the early stages of palisade and spongy parenchyma differentiation, prior to the separation of the cells in the latter to give inter-cellular spaces.

The ascus initials are formed subcuticularly at the time of maturation of the leaf and the asci which develop discharge their spores immediately so that the entire cycle from the time of infection to the time of spore discharge takes but a few weeks. After the spores are discharged the fungus dies and the diseased portions of the leaf become quite flaccid. In all cases except those in which small areas of the leaf are diseased the leaves drop from the tree soon after.

There is no evidence that the fungus ever becomes perennial in the attacked twigs. The ascospores, or sprout conidia which form from these, live through the summer and winter lodged in the crevices of the bark and upon the scales of the dormant buds. Possibly they may also persist in the soil especially as it has been shown that they can remain viable in dry sterile soil for more than a year. Since the spores bud quite readily in very dilute nutrient solutions and large numbers of budding conidia were found in all of the material collected in the spring for sectioning, it seems altogether likely that a certain amount of growth is made whenever the trees are wet with rain for any extended period. This, together with the experimental evidence that the sprout conidia can survive under extremely dry conditions for more than a year, makes it most probable that the spores of *Taphrina deformans* actually become part of the normal surface flora of peach trees in districts where leaf curl is present. Indeed it is difficult to explain on any other basis the almost universal occurrence of the disease in a year immediately following one in which virtually no leaf curl developed. For example, in the year 1930 it was difficult to find curled leaves in the unsprayed orchard which was used in the following year for the spraying experiments. Yet, in 1931, with the exception of the sprayed trees, this entire orchard was uniformly and severely diseased. Since each diseased area on a leaf is caused by the infection from at least one spore the distinctly limited amount of inoculum which was liberated in 1930 could not possibly have caused such a severe outbreak in 1931 had not this increased enormously during the interval. This increase is probably to be accounted for by saprophytic development of sprout conidia on the trees in exactly the same way as occurs in the wild yeasts. While one hesitates to carry this analogy too far, the striking similarity between the behaviour of the budding spores of *T. deformans* and the cells of the wild yeasts and related organisms makes it easy to see how some of the latter may have arisen from somewhat similar parasites whose hosts have become exterminated during the process of evolution or have developed complete immunity to their attack.

The ability of the sprout conidia to bud and multiply upon the surface of the trees explains to some extent the erratic results which sprays give in very wet seasons. For unless all the spores on the entire tree are killed by the fungicide they are likely to be carried from the parts of the tree which the spray has not covered to the sprayed portions, where, if the rains have been heavy, most of the fungicide will have been washed away. Reasoning thus the results obtained in 1932 from the spraying experiments can be quite readily explained. The best control was given by the spray applied on April 27, at which date the buds were beginning to open but no infection had occurred, whereas the sprays applied before and after this were decreasingly efficient (Table 3). As the chart in Figure 5 shows, heavy rains fell in the early and middle part of April and these undoubtedly washed away part of the fungicide from the limbs which had been sprayed prior to their occurrence and at the same time carried fresh inoculum to these from the unsprayed limbs. Although the experimental material used in 1932 was particularly favourable for demonstrating this type of spread, since there were a number of unsprayed branches on each tree, the same principle would operate to a greater or lesser extent in any orchard in which the dormant spray had not been thoroughly applied. The sharp decrease in the efficiency of the sprays applied after April 27 is due to infections occurring before the spray applications were made. The two factors therefore which govern the efficiency of a spray in a given season are the thoroughness with which the spray is applied and the time which elapses between the date of its application and the period favourable to infection. Because of this it is obvious that thoroughness is of greater importance in fall spraying than in spring applications because the spores which are not killed have a much longer period in which to multiply and spread than is the case with those missed by an application made in the spring.

In both 1931 and 1932 the sprays applied after the period during which most of the infection is presumed to have occurred were more effective in controlling the disease than was expected. Thus in 1931 the spray of April 29 controlled more than one-half of the infection which developed that year, although the most extended period of cold wet weather which occurred that spring immediately preceded the application of this spray. Likewise in 1932, although by far the most extended cold wet period was from May 6 to May 12, the spray of May 12 reduced the incidence of curl by one-half. These results at once suggest that the fungicide can reach and inhibit the fungus during the early stages of the infection process. The material which was collected on May 12, 1932, showed the fungus in all stages of its early development, ranging from the early stages of penetration to a number of well established infections which were beginning to have their effect upon the cells of the host. There were also a large number of infections at the intracuticular stage and it seems quite possible that the fungicide was able to diffuse through the very thin layer of cuticle surrounding those and inhibit their development. The fact that peach foliage is very susceptible to lime sulphur injury renders this hypothesis all the more probable.

Although the problem of why leaf curl infection should occur only in the spring and not throughout the summer is unsolved as yet, the data obtained from this investigation and from work now in progress suggest at least one reasonable explanation other than that penetration is limited by unfavourable external conditions. The fact that the fungus does not spread in the leaf after the latter has reached a certain stage in its ontogeny suggests that, as the peach leaf matures, its tissues develop a definite resistance to attack and this might explain why well-developed leaves never become diseased. This does not, however, account for the apparent resistance of the leaves which are developing during the summer from the tips of the shoots, since these must all pass through developmental stages comparable to those experienced by leaves which develop in the spring. Still it must be remembered that the leaves in the summer go through their development much more quickly than do the leaves which are formed in the early spring and it may be that the period of their susceptibility is passed before infection can become established. This phase of the problem is receiving further attention.

The nuclear cycle of *Taphrina deformans* is of special interest in view of the emphasis at present being placed upon nuclear behaviour as one of the main considerations in determining phylogenetic relationships among the fungi. Morphologically the genus Taphrina displays characters which have caused it to be considered a primitive one among the Ascomycetes. The fruiting structure in particular is unspecialized as compared with the apothecium of the Discomycetes and the perithecium of the Pyrenomycetes. Nevertheless the work of Wieben (*10*) has indicated that cytologically there is a very highly developed type of life cycle in this group. Wieben has described the nuclear cycle in *Taphrina epiphylla* and *T. Klebahni* as follows. The ascospores are uninucleate and haploid, these bud in nutrient solutions producing sprout conidia which are also uninucleate, the sprout conidia of the third or subsequent generation copulate, the nucleus of one passing into the other cell but not fusing with the nucleus of it. This binucleate cell then germinates to produce a long septate germ tube (*suchfaden*), to the tip of which the associated nuclei move without dividing. Wieben believes that this germ tube is the infection hypha and that the dicaryon condition of the mycelium arises from the division of the two nuclei at its tip. Karyogamy occurs just prior to the formation of the ascus and is immediately followed by meiosis which gives rise to the eight haploid ascospores. Now, as Kniep (*4*) has pointed out, cytologically this is essentially similar to the condition obtaining in *Ustilago violacea* where the sporidia copulate prior to infection and the mycelium within the host is binucleate. This may be illustrated graphically as shown in Figure 9.

This investigation has shown that in *Taphrina deformans* the nuclear cycle differs from that presented by Wieben for *T. epiphylla* and *T. Klebahni*, since in *T. deformans* no copulation occurs prior to infection and the binucleate condition is brought about simply by the division of the haploid nucleus of the spore at the time of infection to give a pair of nuclei. The contents of the spore pass into the cuticle of the host and then these two nuclei divide conjugately giving rise to other pairs thus giving rise to the binucleate mycelium. The nuclear situation in *T. deformans* is therefore quite comparable to that of a short-cycle rust of the *Puccinia malvacearum* type, in which, as Ashworth (*1*) has shown, the diploid phase is initiated directly from haploid mycelium derived from monobasidiospore infection. The nuclear situation in *Taphrina epiphylla* and *Ustilago violaceae* is essentially the same as that of a long-cycled rust of the *Puccinia graminis* type, for two haploid spores of opposite potentiality are needed before these fungi can complete their life cycle. Therefore if *P. malvacearum* is, as Jackson (*5*) suggests, a reduced form of rust from the long-cycled type, we are justified in suggesting that the same process of evolution which is occurring in the rusts may be likewise occurring in the genus Taphrina of the Ascomycetes, and that *T. deformans* represents a short-cycled form evolved from the long-cycled *T. epiphylla* type. In *T. epiphylla* and *U. violaceae*, as in the long-cycled rusts though sexual structures are eliminated or extremely reduced, a provision for hybridity is retained. In *T. deformans* and *P. malvacearum* hybridity has been lost and each haplont becomes self-fertile (Figure 10).

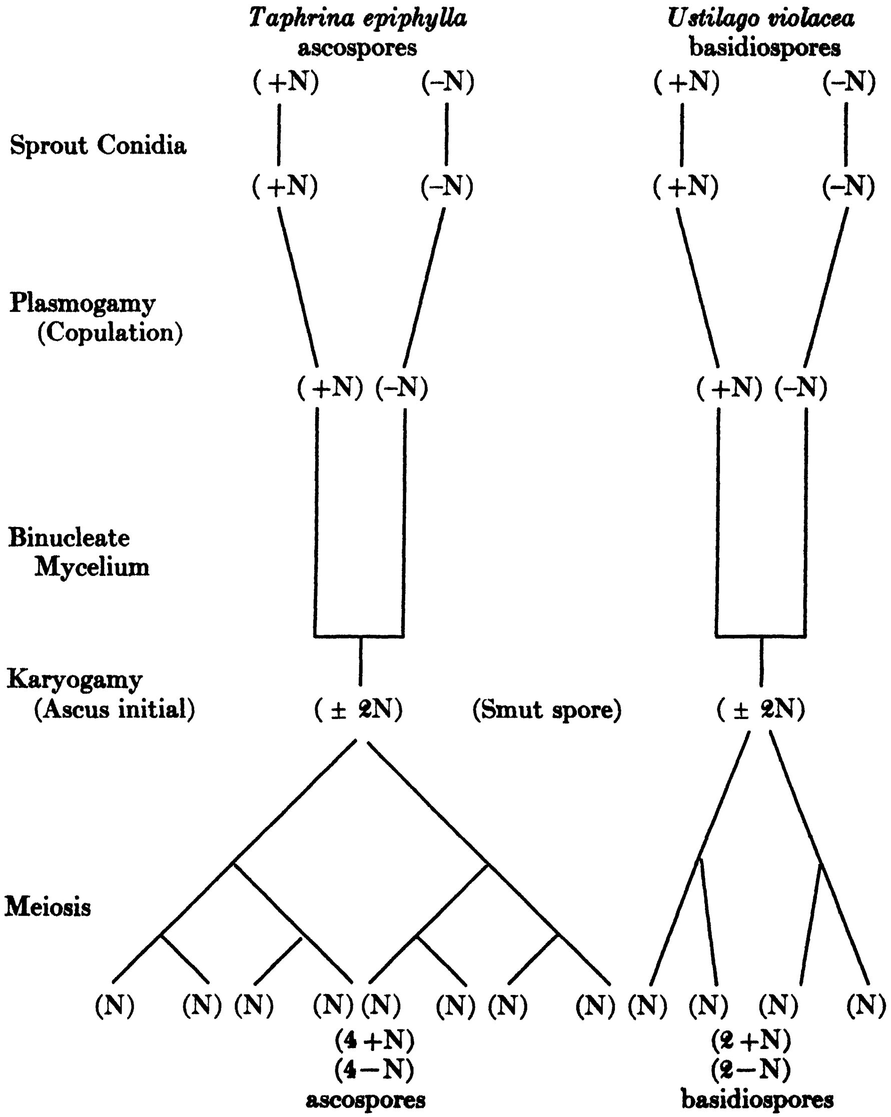

Figure 9

## SUMMARY

1. The life history and parasitism of *Taphrina deformans* have been investigated.

2. Carefully timed spraying experiments indicate that infection occurs in the spring just as the leaf buds are unfolding. In the Niagara district summer infection rarely, if ever, occurs.

3. The ascospores or sprout conidia derived from them have been shown to persist through the summer and winter lodged on the twigs and buds of the peach. From there they are washed to the opening leaf buds by the spring rains.

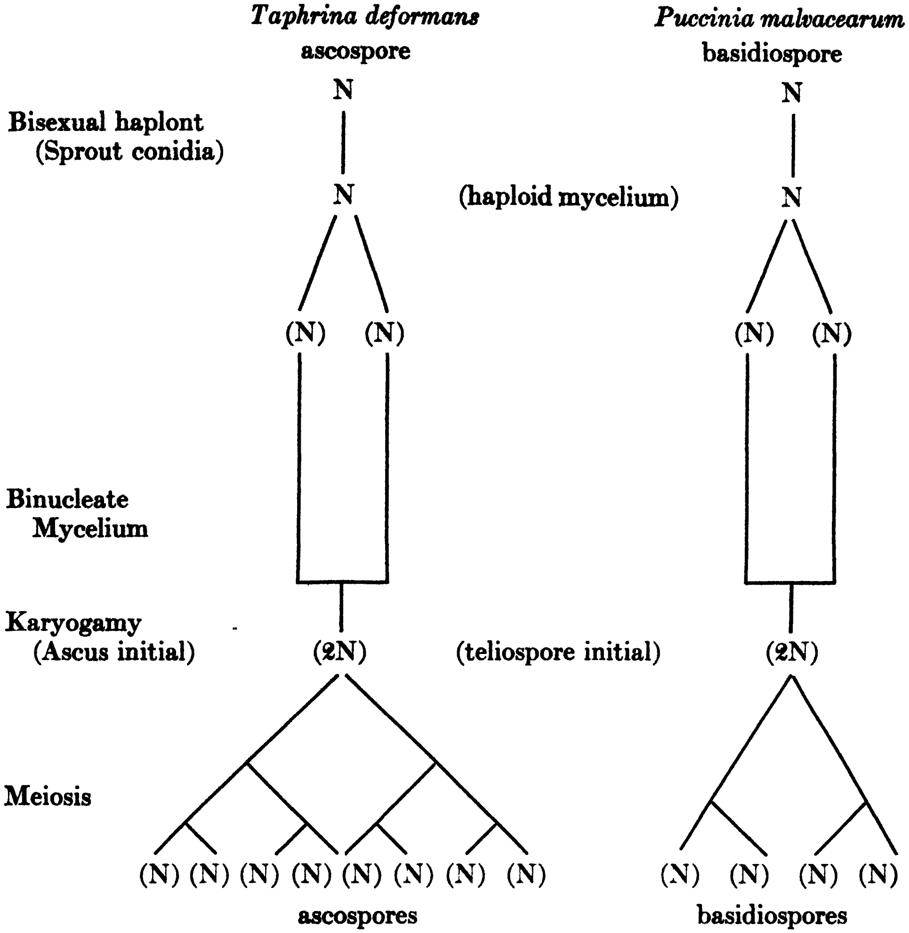

Figure 10

4. Penetration may occur from either surface of the leaf. A spore about to initiate infection produces a short hypha which attaches itself to the leaf surface, and the contents of the spore pass through this into the cuticle where a limited growth is made.

5. From the cuticle the fungus penetrates between the epidermal cells, and for a time grows out in all directions among the parenchyma cells below.

6. The mycelium is irregular and at first is very thin and without septa but later becomes much thicker and numerous cross walls are laid down.

7. Invaded tissues become hypertrophied, the response being apparently confined to the cells in contact with the mycelium.

8. The spores possess a single haploid nucleus which divides as the bud is being formed and the daughter nucleus migrates into the bud. When infection occurs this daughter nucleus appears to assume a conjugate relationship with the mother nucleus and both migrate into the penetration tube. Subsequent divisions are conjugate and one or more pairs of nuclei are found in each cell when the mycelium becomes septate. Thus the entire life cycle

can be initiated by a single spore and no copulation of sprout conidia such as has been reported for *Taphrina epiphylla* and *T. Kelbahni* occurs in this species.

## ACKNOWLEDGEMENTS

The investigation reported upon herein has been carried on as a joint project between the Department of Botany of the University of Toronto and the Provincial Horticultural Experiment Station at Vineland, Ontario. I wish to express my indebtedness to Professor D. L. Bailey, at whose suggestion the problem was undertaken, for his constant help and encouragement. Acknowledgements are also due to Professor H. S. Jackson of the Department of Botany and to the staff of the Ontario Horticultural Experiment Station, Vineland, for their unfailing co-operation.

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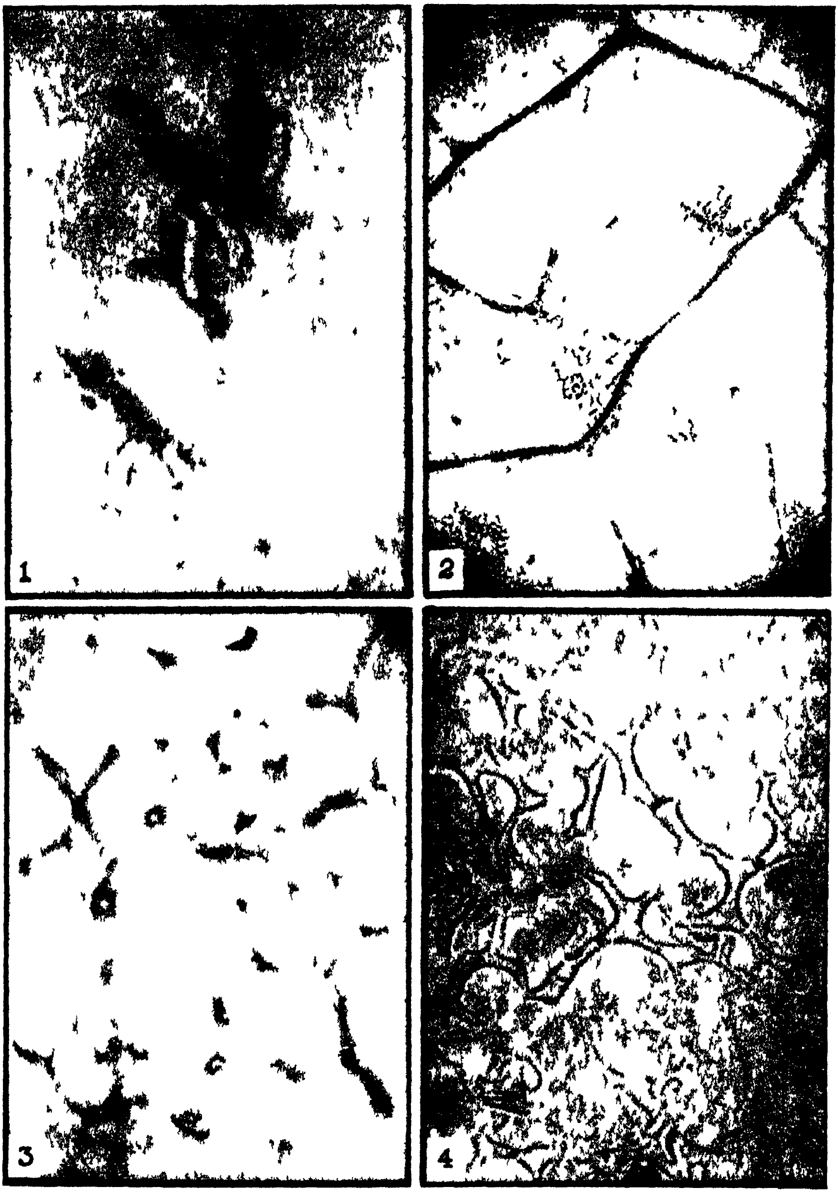


PLATE II

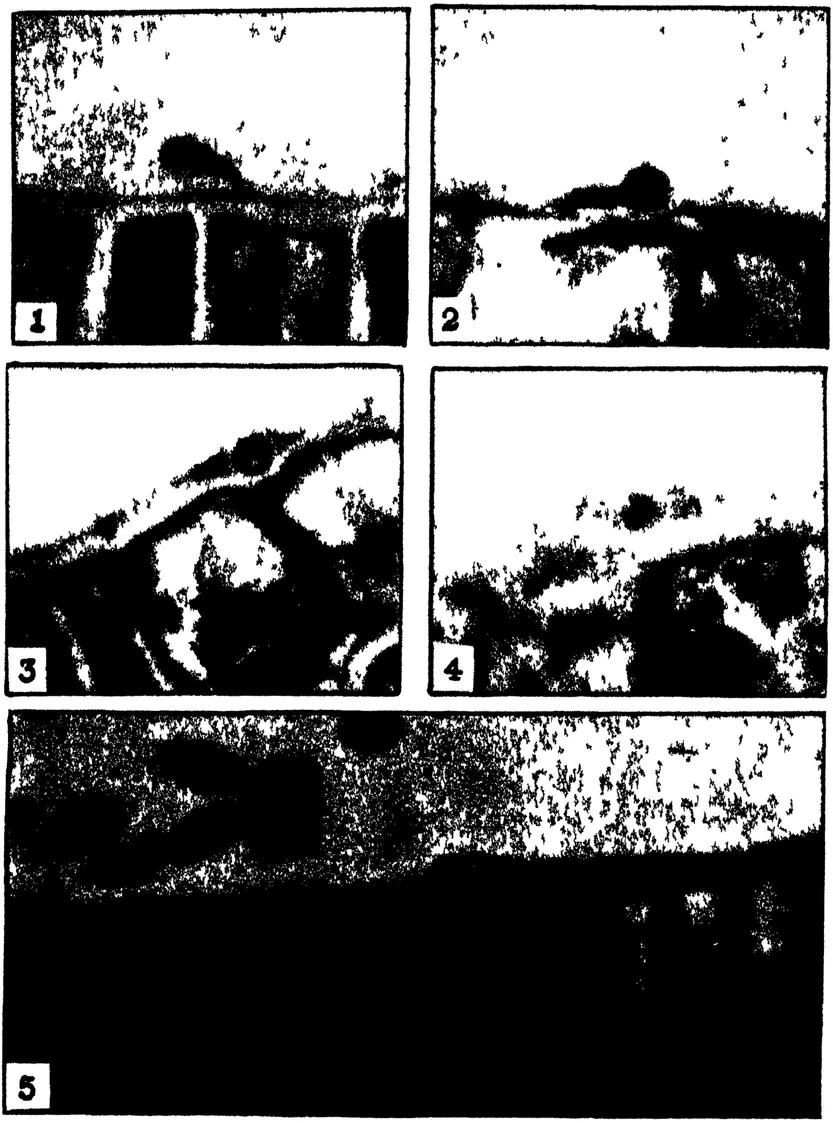
The mycelium of *T deformans* at various stages of development from leaves cleared in lactophenol

1 The early stages of infection showing intracuticular mycelia developed from six separate infections X800

2 The spread of the mycelium from a number of points of infection X100

3 The mycelium during the initial stages of its invasion of the mesophyll X1200

4 A later stage than 3 just prior to the formation of ascogenous hyphae X400.



## PLATE I

1 and 2 The initial stages of penetration by *T deformans* Stained with iron alum haematoxylin X1960

3 and 4 Intracuticular mycelium showing nuclei Stained with iron alum haematoxylin X1960

5 Intracuticular mycelium stained with Flemming's triple stain X1400

# THE NECESSITY FOR GROWING LEGUMES ON GRAY WOODED SOILS

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[Received for publication December 12, 1933]

The prairie provinces of Canada have vast areas of gray wooded soils similar to those found in Alberta. Results obtained by the use of legumes and fertilizers on such wooded soils in Alberta should be of interest to scientists and farmers in other districts where similar soils occur. The following results report experiments for the years 1930 to 1933 carried out on the Breton Experimental Field[2].

The soil is typical of the gray wooded soil belt of Alberta, and has been previously described (*3*, *4*, *5*). These soils are of relatively low initial fertility and do not possess the most desirable physical properties owing to their great tendency to bake when dry. They have suffered considerably from leaching (*1*, *2*), and are likewise of a low order with respect to their phosphorus and nitrogen content. As a consequence, satisfactory crop yields are seldom obtained except, possibly, for the first year following a good fallow, and even then the yields are not as great as from the more fertile soils.

On the other hand these soils are not sufficiently acid to prevent the growth of any of the legumes, but much better growth is obtained with fertilizers, especially in cases where nitrogen and phosphorus are applied. No difficulty has been encountered in obtaining splendid inoculation with the legumes. At the same time we have always obtained very good increases whenever nitrogen has been applied to the legumes as well as to the cereals.

The greater part of the yield data from our experiments with the wooded soils is omitted from the present discussion. However, the following results are sufficient to show the great value and necessity of growing legumes and applying fertilizers if the poorer wooded soils are to be made sufficiently fertile to produce satisfactory crop yields. Part of the yields from Series A. B. C. D and E of the Breton Experimental Field are reported in the following tables. Each series consisted of 11 plots treated as follows:

Plot 1 Check
" 2 Manure
" 3 Nitrogen, phosphorus and potassium.
" 4 Nitrogen
" 5 Check
" 6 Lime
" 7 Lime and phosphorus
" 8 Phosphorus
" 9 Manure and phosphorus
" 10 Nitrogen and phosphorus
" 11 Check

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[1] Professor of Soils.

[2] Grateful acknowledgement is made to other members of the Soils Department who assisted in the experiments herein reported.

The applications of the manure and of the lime were made every alternate year, whereas the other fertilizers were applied annually. The fertilizers were applied with the drill, but across the grain rows and not with the seed. Direct application with the seed would be better practice.

The first four series consist of a rotation of legumes to be plowed under, wheat following legumes, oats following wheat, barley nursing legumes; whereas Series E is wheat grown continuously except when necessary to fallow for weed control.

Oats were grown on the entire field in 1929. Thus the different rotation crops in 1930 all followed oats. The legume crop to be plowed under (Series A) in 1930 consisted of field peas. Barley nursing clovers was grown on Series B, oats on Series C, wheat on Series D and E.

## YIELDS OF CLOVER HAY

The yields of clover hay grown and plowed under for the three years (1931 to 1933) are reported in Table 1.

It will be seen that some fertilized plots doubled, or, in some cases, tripled the yields obtained from the check plots. The fertilizers, with the exception of manure, gave decided increases in yield. The manure gave only slight increases during the first two years, but for 1933 after the second application had been made the yield of the manured plot was double that of the checks. The average increase in yields for the manured plots for the three years was a little over 1/3 of one ton. Lime alone has given increases for the clovers of more than ¾ of a ton. The increases for the other fertilizers have all been from 1¼ to 1½ tons. In general there has been a slight tendency for the yields on the fertilized plots to increase between the years 1931 and 1933. The lime plot, however, gave a smaller yield in 1933

TABLE 1.—YIELDS OF MIXED CLOVER HAYS* AND INCREASES FOR FERTILIZERS. BRETON EXPERIMENTAL FIELD (1931-33)

| Plot | Fertilizer treatment | Clover hay. Lbs. per acre | | | Average yield for 3 years | Average increase for 3 years | Lbs. N. plowed under in clover crops Ave. 3 years |
|---|---|---|---|---|---|---|---|
| | | Series B 1931 | Series C 1932 | Series D 1933 | | | |
| 1, 5, 11 | None | 1922 | 1703 | 1678 | 1768 | — | 36.2 |
| 2 | M | 2208 | 1665 | 3495 | 2456 | 688 | 50.9 |
| 3 | NPK | 3822 | 4395 | 6085 | 4767 | 2999 | 144.0 |
| 4 | N | 5140 | 3160 | 4380 | 4227 | 2459 | 91.3 |
| 6 | L | 3574 | 3835 | 2736 | 3382 | 1614 | 68.0 |
| 7 | LP | 4087 | 4515 | 4550 | 4384 | 2616 | 101.3 |
| 8 | P | 4055 | 4230 | 4495 | 4260 | 2492 | 92.9 |
| 9 | MP | 4047 | 4510 | 5460 | 4672 | 2904 | 103.3 |
| 10 | NP | 3734 | 4220 | 6020 | 4658 | 2890 | 105.3 |

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* Series B. and C consisted of a mixture of sweet clover and alsike clover, whereas Series D was sweet clover and altaswede (red clover).

than in either of the previous two years. The clovers were grown on these plots only once, but each plot had received fertilizers, as previously stated, every year from 1930 to 1933 with the exceptions of the manure and the lime plots, in which cases these fertilizers were applied only twice during this same period. The average yields of clovers from the last four plots (7 to 10) for the three years were about equal. However, in connection with the subsequent grain yields from these same plots it will be seen at a later point that the yield from the phosphorus plot (Plot 8) was decidedly less than any of the other three plots just mentioned. When crops of the magnitude of those reported in Table 1 are plowed under it is to be expected that there would be varying results in subsequent grain crops, since the clovers plowed under contained different quantities of plant foods. This is indicated in the last column of the table, which shows that the check plots contained only 36 pounds of nitrogen (in the clover) when compared with the higher-yielding clover plots which contained upwards of 100 pounds of nitrogen.

## YIELDS OF WHEAT, OATS AND BARLEY

The turning under of legume crops has given decided stimulus to the succeeding crops, and the best results were obtained in such practices as the incorporation of a part or all of the legume crop, together with the application of fertilizers. Certain of the fertilizers gave very good increases when applied to cereals following cereals, but the response was much greater for these fertilizers when they were used as supplements to the clovers. All fertilizers when used in conjunction with the clovers gave good responses, but some of the fertilizer treatments were not economical when used in the absence of clovers. The turning under of clovers alone gave fairly good responses, but turning under of clovers was several times more effective when in conjunction with the use of fertilizers. The use of fertilizers alone or of clovers alone was not adequate for the production of maximum crop yields. However, in the practice of the combined use of fertilizers and the plowing under of clovers, the yields obtained were of the same order as those obtained from the black soil areas. The above practice doubled the productive power of the wooded soils, and the value of clover was of the same order as that of the fertilizers.

Wheat yields after oats, after fallow, and after clover plowed under, are reported in Table 2.

The yields of wheat after oats were from 8 to 19 bushels less per acre than wheat after fallow for similarly treated plots, whereas the yields of wheat after oats were from 11 to 31 bushels less than wheat after clover plowed under, with the exception of the check plots. Similar comparisons might be made for wheat after fallow. This gives some idea of the effect of the fertilizers when wheat follows oats, wheat follows fallow and wheat follows the plowing under of clovers. The individual increases for fertilizers in each of the above three systems are also reported in Table 2, where it will be seen that in the case of wheat after oats only two of the fertilizers gave increases of the order of above 9 bushels per acre, compared with four of the fertilized plots in the wheat after fallow series, which gave increases of approximately 13 bushels per acre, and five of the fertilized plots in the wheat after clover system gave increases of 20 bushels or more per acre, with the other three fertilized plots giving increases of over 8 bushels. It will be seen also that the check plots under the fallow system out-yielded the check

TABLE 2.—YIELDS OF WHEAT AFTER OATS, WHEAT AFTER FALLOW, WHEAT AFTER CLOVER PLOWED UNDER; AND INCREASES FOR FERTILIZERS. BRETON EXPERIMENTAL FIELD (1930-1933)

| Plot | Fertilizer treatment | Wheat yields. Bus. per acre | | | Increases for fertilizers. Bus. per acre | | |
|---|---|---|---|---|---|---|---|
| | | Wheat after oats 1930 | Wheat after fallow 1933 | Wheat after clover plowed under 1933 | Wheat after oats 1930 | Wheat after fallow 1933 | Wheat after clover plowed under 1933 |
| 1, 5, 11 | None | 15.4 | 25.0 | 19.8 | — | — | — |
| 2 | M | 14.7 | 27.8 | 28.8 | - .7 | 2.8 | 9.0 |
| 3 | NPK | 25.3 | 38.7 | 46.3 | 9.9 | 13.7 | 25.5 |
| 4 | N | 19.6 | 38.2 | 40.0 | 4.2 | 13.2 | 20.2 |
| 6 | L | 17.0 | 27.5 | 28.4 | 1.6 | 2.5 | 8.6 |
| 7 | LP | 17.5 | 33.0 | 39.8 | 2.1 | 8.0 | 20.0 |
| 8 | P | 17.5 | 25.6 | 32.9 | 2.1 | 0.6 | 13.1 |
| 9 | MP | 19.0 | 37.9 | 47.3 | 3.6 | 12.9 | 27.5 |
| 10 | NP | 24.5 | 37.7 | 55.4 | 9.1 | 12.7 | 35.6 |
| Vertical averages | | | | | 4.0 | 8.3 | 19.9 |

plots where the clovers had been plowed under. However, the increases due to fertilizers were in all cases materially greater for the series where clover had been plowed under. The increases for the lime treatment (Plot 6) and for the phosphorus treatment (Plot 8) are of a very small order, both in the series where wheat follows oats and where wheat follows fallow, but both of these treatments have given significant increases where wheat follows clover plowed under.

A somewhat better idea of the effectiveness of fertilizers in the above systems may be obtained by comparing the vertical averages for the fertilizer increases, where it will be seen that the average increases of all the fertilizer treatments in the wheat after oats system amounted to 4 bushels of wheat per acre. A similar figure for the wheat after fallow was 8.3 bushels, whereas wheat after clover plowed under showed average increases for the fertilizer treatments amounting to 19.9 bushels.

From the above wheat yields the following significant fact is brought out. The best fertilizer treatments where wheat followed oats gave yields of the order of 25 bushels of wheat per acre, whereas the best fertilizer treatments after clover had been plowed under gave wheat yields of the order of 45 to 55 bushels per acre. Thus the yields of wheat have been doubled with the plowing under of only one crop of clover and the use of fertilizers.

Similar results are shown for the oat and barley crops. The yields for these two crops are reported in Table 3.

Here it is seen that the oat crop grown the second year after clovers had been plowed under gave yields in all cases much greater than oats after oats, and in some cases the yields were more than doubled, thus showing that the residual effect of the plowed-under clovers had been maintained well into the second year. The important effect of the plowing under of clovers is likewise shown in the comparison of the barley yields with yields from similarly treated plots where barley followed oats. The data show that where oats followed oats three of the fertilizer treatments gave increases of the order of 14 to 17 bushels, and where oats were grown the second year after the clovers had been plowed under, five of the fertilizer treatments gave increases varying from about 18 to about 49 bushels. Similarly barley after oats showed three of the fertilizer treatments giving increases from about 12 to about 20 bushels, whereas when barley followed clover plowed under, six of the eight fertilized plots gave increases varying from 17 to 41 bushels.

The effect of the increase of the fertilizers after clovers had been plowed under as compared with the cereals following cereals is shown in another manner by the vertical averages. Here it is seen that the average effect of all the fertilizer treatments on oats after oats was equivalent to 8.9 bushels increase, whereas the average effect for oats (second crop) after clovers had been plowed under was 22 bushels. The corresponding figures for the barley crop were 8.7 and 23.9 bushel increases respectively.

Responses to the use of fertilizers and clovers on these wooded soils are clearly shown by the relative yields from the various plots of wheat following clover (Figure 1).

TABLE 3.—YIELDS OF OATS AND BARLEY AND INCREASES FOR FERTILIZERS. BRETON EXPERIMENTAL FIELD (1930-1933)

| Plot | Fertilizer treatment | Oat yields Bus. per acre | | Increases for fertilizers Bus. of oats | | Barley yields Bus. per acre | | Increases for fertilizers Bus. of barley | |
|---|---|---|---|---|---|---|---|---|---|
| | | Oats after oats 1930 | Oats after wheat after clover plowed under 1933 | Oats after oats 1930 | Oats after wheat after clover plowed under 1933 | Barley after oats 1930 | Barley after clover plowed under 1933 | Barley after oats 1930 | Barley after clover plowed under 1933 |
| 1, 5, 11 | None | 27.1 | 41.2 | — | — | 22.3 | 27.5 | — | — |
| 2 | M | 25.3 | 50.1 | -1.8 | 8.9 | 22.5 | 46.2 | 0.2 | 18.7 |
| 3 | NPK | 44.3 | 62.2 | 17.2 | 21.0 | 42.5 | 68.6 | 20.2 | 41.1 |
| 4 | N | 44.7 | 90.3 | 17.6 | 49.1 | 33.9 | 51.2 | 11.6 | 23.7 |
| 6 | L | 32.9 | 50.7 | 5.8 | 9.5 | 27.1 | 39.0 | 4.8 | 11.5 |
| 7 | LP | 36.3 | 58.9 | 9.2 | 17.7 | 24.6 | 44.7 | 2.3 | 17.2 |
| 8 | P | 32.9 | 50.1 | 5.8 | 8.9 | 27.3 | 39.5 | 5.0 | 12.0 |
| 9 | MP | 30.4 | 66.2 | 3.3 | 25.0 | 29.2 | 58.3 | 5.9 | 30.8 |
| 10 | NP | 41.5 | 77.0 | 14.4 | 35.8 | 42.2 | 63.8 | 19.9 | 36.3 |
| Vertical averages | | | | 8.9 | 22.0 | | | 8.7 | 23.9 |

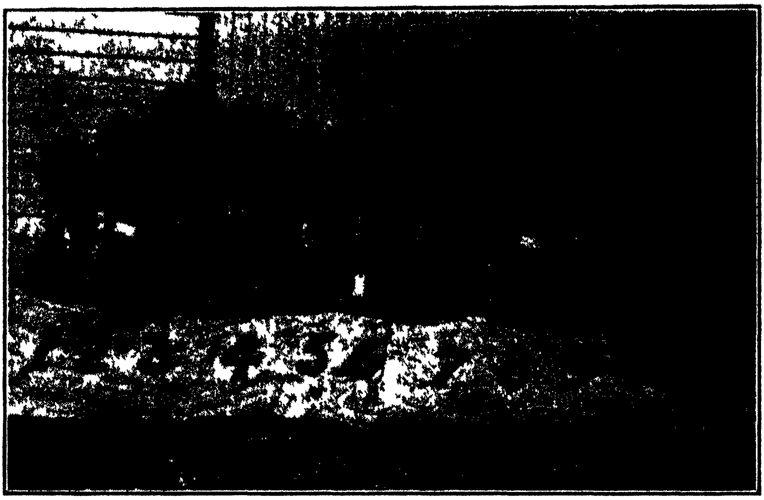

Figure 1 Each bundle represents 4 sq yds The differences in yields (see Table 2) vary from 19 8 to 55 4 bushels

Figure 2 Mixture of sweet and altaswede clover 1933 The check plot yielded 1726 lbs whereas the nitrogen plot yielded 4380 lbs

## Value of Clover Plowed Under

The effect of the various fertilizers as expressed by increased yields of wheat, oats and barley with and without clover plowed under, has been shown in Tables 2 and 3. These data, however, did not set out the specific effect of clover. The increases caused by clover may be obtained by comparing horizontally the yields from similarly fertilized plots. Such comparisons are shown in Table 4 where each increased yield represents the superiority of clover over the series without clover.

TABLE 4.—INCREASED YIELDS OF WHEAT, OATS AND BARLEY DUE TO CLOVER PLOWED UNDER AS COMPARED WITH WHEAT, OATS AND BARLEY FOLLOWING OATS AND WHEAT FOLLOWING FALLOW (BUS. PER ACRE INCREASE)

| Plot | Fertilizer treatment | Increased yields (bus.) of wheat due to clover plowed under | | Increased yields (bus.) of oats (2nd crop) due to clover plowed under | Increased yields (bus.) of barley due to clover plowed under |
|---|---|---|---|---|---|
| | | Compared with wheat after oats | Compared with wheat after fallow | Compared with oats after oats | Compared with barley after oats |
| 1, 5, 11 | None | 4.4 | -5 2 | 14 1 | 5.2 |
| 2 | M | 14 1 | 1 0 | 24 8 | 23.7 |
| 3 | NPK | 21.0 | 7 6 | 17 9 | 26.1 |
| 4 | N | 20.4 | 1.8 | 45 6 | 17.3 |
| 6 | L | 11 4 | .9 | 17 8 | 11.9 |
| 7 | LP | 22 2 | 6.8 | 22.6 | 20 1 |
| 8 | P | 15.4 | 7 3 | 17.2 | 12.2 |
| 9 | MP | 28 3 | 9 4 | 35.8 | 29.1 |
| 10 | NP | 30 9 | 17.7 | 35.5 | 21 6 |
| Vertical averages | | 18.7 | 5.3 | 25.7 | 18.6 |

The plowing under of clover has been superior to the other systems in every case, with the single exception of the check plots on fallow. The value of clover has been much greater when compared with the wheat after oats than when compared with the wheat after fallow, but the plowing under of clover has given greater yields than fallow for every fertilizer treatment; as an average of all the fertilized wheat plots the clover has given 6.3 bushels more than the fallow and 20.5 bushels more than the wheat after oats. The corresponding figures for the increases due to fertilizers in the above two systems are 8.3 and 19.9 bushels respectively. The value of clover as measured by the increased oat yields has varied from 14 bushels for the check plot to almost 46 bushels for the nitrogen plot (Plot 4). Similarly the increases in barley due to the clover varied from 5.2 bushels for the check to 29.1 bushels for the manure and phosphorus plot (Plot 9).

It should be kept in mind that the increases shown in the oat yields are those which have carried over into the second year after the clover had been plowed under. Thus we are justified in adding the increases in oat yields to the increases in wheat yields (column 1) as indicating the value of the plowed-under clovers. It is too early to say whether or not the effect of the plowed-under clover will be carried over into the third year.

It will be seen that the increases due to the clover are approximately of the same magnitude as the increases due to the fertilizers previously discussed. It should again be pointed out that the increases due to the clover alone, where fertilizers had not been applied, were of the same order as the increases due to the fertilizers alone without clover plowed under. However, the value of the fertilizer and of the clover was materially increased when these were used jointly. This is to be expected, since as previously shown in Table 1, the amount of clover plowed under was largely dependent upon the fertilizer used.

If the average increases for fertilizers, as shown in Tables 2 and 3, and the average increases for clovers obtained from the fertilized plots shown in Table 4, are brought together in a summary table, a more comprehensive idea is obtained of the relative effects of fertilizers and of clovers. Such a summary is shown in Table 5.

TABLE 5.—INCREASES OF WHEAT, OATS AND BARLEY FOR FERTILIZERS AND FOR CLOVER PLOWED UNDER; BRETON EXPERIMENTAL FIELD
(Increases reported as bushels per acre)

| | Wheat | | | Oats | | Barley | |
|---|---|---|---|---|---|---|---|
| Average increases for all fertilizers (Vertical averages from Tables 2 & 3) | Wheat after oats 1930 | Wheat after fallow 1933 | Wheat after clover plowed under 1933 | Oats after oats 1930 | Oats (2nd crop) after clover plowed under 1933 | Barley after oats 1930 | Barley after clover plowed under 1933 |
| Increases for fertilizers (Bus. per acre) | 4 0 | 8 3 | 19 9 | 8 9 | 22.0 | 8 7 | 23 9 |
| Comparisons of check with and without clover, also fertilized plots with and without clovers | Clover checks over checks without clover | Clover and fertilizers over fallow and fertilizers | Clover and fertilizers over fertilizers without clover | Clover checks over checks without clover | Clover and fertilizers over fertilizers without clover | Clover checks over checks without clover | Clover and fertilizers over fertilizers without clover |
| Increases for clovers (Bus. per acre) | 4 4 | 6 3 | 20 5 | 14 1 | 27 1 | 5 2 | 20.3 |

It is admitted that such a summary did not indicate the best fertilizers or the poorest fertilizers, and that the value of the least effective fertilizers was small, whereas the value of the more effective fertilizers was great. However, these average figures do show in general exactly the relative effect of fertilizers and clover when used alone and as influenced by each other. It is seen that clovers alone gave an increase of 4.4 bushels of wheat, 14.1 bushels of oats, and 5.2 bushels of barley, whereas fertilizers alone gave increases of 4.0 bushels of wheat, 8.9 bushels of oats, and 8.7 bushels of barley. When clovers were plowed under and fertilizers used in addition, the value of the clover gave the following increases: Wheat 20.5 bushels, oats 27.1 bushels, barley 20.3 bushels, whereas the increases for the fertilizers were respectively—wheat 19.9 bushels, oats 22.0 bushels, and barley 23.9 bushels.

## SUMMARY

Results are reported from the Breton Experimental field for the years 1930 to 1933 giving crop yields for clovers, wheat, oats and barley on the gray wooded soils of Alberta. In their virgin condition these soils are relatively infertile, but with the growth of legumes and the use of fertilizers they can be converted into relatively productive soils within the period of a few years.

With the exception of manure, all the fertilizers used gave decided increases in the clover yields. The average increase in yields for the manured plots for the three years was a little over 1/3 of one ton. Lime alone gave increases for the clovers of over ¾ of a ton. The increases for all other fertilizers have been from 1¼ to 1½ tons. The clovers were grown on each plot only once. The extreme variations in crop yields ranged from a little under a ton for the checks to approximately three tons for some fertilized plots. These clovers were plowed under in order to determine the effect upon the subsequent grain crops. The amount of nitrogen contained in the plowed-under clover varied from about 36 pounds for the checks to 144 pounds for the highest yielding plot.

The plowing under of clovers alone gave fairly good responses, but the plowing under of clovers was several times more effective when in conjunction with the use of fertilizers. The use of fertilizers alone or clovers alone was not adequate for the production of maximum crop yields. The practice of plowing under of clovers in conjunction with the use of fertilizers doubled the productive power of the wooded soils, and the value of the clover was of the same degree as that of the fertilizers.

The yields of wheat after oats were from 8 to 19 bushels less per acre than wheat after fallow for similarly treated plots, whereas the yields of wheat after oats were from 11 to 31 bushels less than wheat after clover plowed under. In the series of wheat after oats only two of the fertilizers gave increases above 9 bushels per acre, whereas four of the fertilized plots in the wheat after fallow series gave increases of approximately 13 bushels per acre, and five of the fertilized plots in the wheat after clover series gave increases of 20 bushels or more per acre. Similar increases were shown for the barley and oat crop. The effect of the plowed-under clover was maintained at least into the second crop year.

Such data bring out the fact that the plowing under of clovers and the use of fertilizers is of similar value and that both are absolutely necessary if satisfactory yields are to be obtained from these wooded soils. As a general statement covering all three grain crops the results might be expressed as follows: The increases in yields were from 2 to 4 times as great for both the clovers and the fertilizers when used conjointly as when used alone.

The necessity of legumes and the use of fertilizers for the wooded soils becomes apparent when it is remembered: first, that the use of fertilizers doubles the yields of clover; second, that the plowing under of clovers in conjunction with the use of fertilizers has more than doubled the yields of the grain crops, such as wheat, oats and barley; third, that the above increases in the grain crops have resulted from the plowing under of a single crop of clover.

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# CAPITAL INVESTED PER SHEEP RANCH, IN THE MAPLE CREEK AND GREAT SANDHILLS AREA OF SOUTHWESTERN SASKATCHEWAN[1]

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[Received for publication December, 15, 1933]

It may be of interest for those unfamiliar with sheep ranching to know that the production of sheep under range conditions requires a rather heavy capital investment. This is clearly shown by examining the capital structure of sheep ranches in the Maple Creek and Great Sandhills Area of Southwestern Saskatchewan. There was found to be $35,542 invested on the average per ranch or $24.81 per head of sheep. Of this amount $14,337 was invested in land and $9,607 in sheep; these two items made up 67.4% of the total. It should be mentioned that these figures are for 18 ranches which had on the average 1,432 head of sheep per ranch. It is only reasonable to expect a wide variation in the distribution of the fixed capital invested on different ranches as indicated in Table 1. The average for all ranches, however, was found to be 40.4% invested in land, 27% in sheep, 13.5% in buildings and improvements, 7.5% in other live stock, 6.4% in machinery and equipment, and 5.2% in feed and supplies.

TABLE 1.—CAPITAL INVESTED PER RANCH; 18 SHEEP RANCHES MAPLE CREEK AND GREAT SANDHILLS AREA OF SOUTHWESTERN SASKATCHEWAN: AVERAGE 1929, 1930, 1931

| Ranch No. | Value land | Value sheep | Value buildings and improvements | Value other live-stock | Value machinery and equipment | Value feed and supplies | Total investment |
|---|---|---|---|---|---|---|---|
| 85 | 42,498 | 15,087 | 12,502 | 3,166 | 2,875 | 3,529 | 79,657 |
| 28 | 21,375 | 6,845 | 7,625 | 2,207 | 4,567 | 2,803 | 45,422 |
| 55 | 19,377 | 10,158 | 5,623 | 1,154 | 3,323 | 2,577 | 42,212 |
| 88 | 6,552 | 16,095 | 7,448 | 5,468 | 3,462 | 3,024 | 42,049 |
| 43 | 24,332 | 8,299 | 5,668 | 599 | 1,242 | 1,047 | 41,187 |
| 65 | 15,889 | 8,298 | 4,111 | 7,688 | 2,807 | 1,202 | 39,995 |
| 81 | 4,452 | 15,001 | 3,548 | 11,331 | 1,458 | 3,520 | 39,310 |
| 7 | 27,307 | 3,976 | 2,693 | 2,228 | 1,451 | 1,287 | 38,942 |
| 79 | 12,986 | 13,034 | 5,014 | 4,483 | 1,613 | 1,206 | 38,336 |
| 77 | 15,174 | 12,428 | 4,826 | 1,952 | 870 | 2,663 | 37,913 |
| 76 | 14,993 | 12,667 | 3,007 | 1,301 | 2,412 | 943 | 35,323 |
| 92 | 9,113 | 17,668 | 2,887 | 759 | 2,590 | 1,567 | 34,584 |
| 70 | 11,923 | 10,749 | 3,077 | 549 | 2,676 | 2,095 | 31,067 |
| 36 | 9,908 | 6,238 | 4,092 | 1,122 | 2,862 | 1,313 | 25,535 |
| 47 | 9,878 | 7,649 | 2,122 | 953 | 801 | 689 | 22,092 |
| 30 | 5,435 | 4,136 | 5,465 | 885 | 1,713 | 1,310 | 18,944 |
| 45 | 3,837 | 2,226 | 3,163 | 1,312 | 2,318 | 1,710 | 14,566 |
| 5 | 3,039 | 2,374 | 3,361 | 1,090 | 2,045 | 713 | 12,622 |
| Average per ranch | $14,337 | $9,607 | $4,791 | $2,680 | $2,282 | $1,844 | $35,541 |
| Per cent | 40.4 | 27.0 | 13.5 | 7.5 | 6.4 | 5.2 | 100.00 |
| Average capital per head | $10.01 | $6.71 | $3.34 | $1.87 | $1.59 | $1.29 | $24.81 |

The large investment in land was due to the rather high percentage of deeded land as compared with leased land. There was on the average 9,720 acres per ranch of which 1,751 acres or 18% was deeded land and 7,969 acres or 82% was leased land. Of the leased land 88% was Crown land, 5% school land, 3% Hudson's Bay, and 4% open free range.

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[1] The conclusions presented in this preliminary article represent one section of an economic study dealing with various phases of the range sheep industry in Western Canada. The study was started in 1930 and is conducted jointly by the Agricultural Economics Branch and the Experimental Farms Branch of the Dominion Department of Agriculture.

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About fifty years ago when this area was first settled, all range was open and free but the sheep rancher under present conditions must either lease or purchase the land he requires. Much of it has a low carrying capacity which explains the need for such a large area per ranch. It required 5.4 acres per sheep unit on the average for all ranches. The insecurity of tenure in past years has resulted in ranchers purchasing certain lands especially those privately owned to give greater permanency to their business. This land for the most part was bought at a price above the value of such lands for grazing purposes. The value of deeded land averaged about $6.50 per acre without considering buildings and improvements. There is also a capital valuation for lease land since such lands are sometimes bought and sold. A 40 cent capital value per acre aside from improvements was found to be the average estimate given by ranchers for lease land. In some instances the lease was capitalized at the same as the value of the improvements.

Sheep on the range are not kept under woven wire or wolf-proof fence as is the custom in some parts of New Mexico and other southern central states, but are herded in bands of about 1,500. The ranch is generally fenced with two or three strands of barbed wire, which serves not only as a boundary, but also divides the ranch into pastures, and keeps out stray stock. Fencing is a heavy cost on a ranch and in addition to the initial outlay, it must be kept in repair. The value of all fences, buildings, dipping tanks, sheep sheds, barns, range water developments and other improvements was found to be 49 cents per acre on the average per ranch.

The ranchers do not follow the practice of keeping wether lambs for wool production as is the custom in certain sections of Australia and the Union of South Africa. The permanent flock of 1,432 head of sheep found on the average per ranch consisted of 76% breeding ewes, 21% ewe lambs and 3% ram lambs, cull wethers and rams. It should be explained that it is the practice on ranches to keep ewe lambs for replacement and expansion purposes, but they do not become part of the breeding flock until the fall of the second season at which time they are about one and one-half years of age.

On most ranches a few cows are kept for milking purposes and horses are used for riding and farm work although four of the 18 ranches included in this study had tractors.

One of the greatest problems of ranching is to obtain sufficient winter feed. The amount required depends on the snow covering. The native prairie hay is cut in low spots and specially conserved areas. A large amount of Russian thistle, a weed with a succulent stem, is also put up and if cut at the proper time makes suitable feed.

The capital invested in sheep in relation to land and other fixed assets had a marked effect on the income from ranching. The best distribution of capital included a large proportion invested in sheep.

## RESUME

NECESSITE DE LA CULTURE DES LEGUMINEUSES SUR LES SOLS FORESTIERS GRIS. F. A. Wyatt, Département des Sols, Université de l'Alberta, Edmonton, Alta.

Du trèfle, du blé, de l'avoine et de l'orge ont été produits en rotation sur des sols forestiers gris avec l'aide d'engrais chimiques. A l'état vierge ces sols sont relativement infertiles, mais ils peuvent être rendus relativement fertiles en quelques années à l'aide de légumineuses et d'engrais chimiques. L'emploi d'engrais seulement ou de trèfle seulement ne suffit pas. L'augmentation de rendement du grain a été de deux à quatre fois plus grande lorsque le trèfle et les engrais chimiques ont été employés conjointement que lorsqu'on a utilisé seulement l'une ou l'autre amélioration. La pratique d'enfouir du trèfle et l'emploi d'engrais chimiques ont plus que doublé la productivité de ces sols forestiers.

# THE ECONOMIC SITUATION

PREPARED IN THE AGRICULTURAL ECONOMICS BRANCH, DEPARTMENT OF AGRICULTURE, OTTAWA, FROM BASIC DATA COLLECTED BY THE DOMINION BUREAU OF STATISTICS

The upward trend of wholesale prices in Canada was maintained in December. The index rose fractionally from 68.7 to 69.0. Animals and their products, fibres, textiles and textile products, wood, wood products and paper, iron and its products, non-ferrous metals and their products and non-metallic minerals advanced. Vegetable products and chemicals and allied products were lower. The preliminary index for 1933 was 2.2 points higher than that for 1932; even more significant, however, has been the reasonably consistent strength shown during the latter months of the past year in wholesale markets.

*Retail Prices.* The index number of retail prices advanced from 78.1 in November to 78.4 in December. Higher indexes for food and clothing were responsible for the rise in the total index. In this connection it is worthy of note that retail sales on the whole showed improvement during the last five months of 1933. This indicates a growing confidence and to some extent a rise in purchasing power.

*Employment.* Employment conditions continue to improve. The index at January 1st, 1934, was 95.0 as compared with 91.8 at the beginning of December. The actual number of workers employed was slightly less than at December 1st but the seasonal decline was much less than usual and thus the adjusted index was higher.

*Physical Volume of Business.* The index number of the physical volume of business advanced from 85.5 in November to 86.2 in December. This was just 13.6 points above the December 1932 index. Industrial production was 17.4 points above the December 1932 index. During the past month, the index of manufacturing rose 2.4 points. Mineral production was also higher. Iron and steel production advanced strongly but construction was low. It may be of interest to point out that the index of physical volume of business was 125 in 1929; it dropped to 78.7 in 1932; however, in 1933 the index was 79.2. This scarcely indicates the extent to which the falling off in volume of business has been checked. The improvement, however, is evident when it is realized that this index has not been below 82 since last May. The rise in the physical volume of business is perhaps as valuable an index of conditions as is available if a single index is to be taken as a guide. Wholesale prices and volume of business seem to be moving in the same upward direction. Obviously there is a relationship.

*Agricultural Products.* The index of Canadian farm products was fractionally lower in December, due to a rather sharp decline in the index of field products. Grain prices were generally lower and counterbalanced an advance in the index of animal products.

Agricultural marketings reached a low level in December, the index falling to 30.7. The grain index was 24.7 and the live stock index 57.5. Hog marketings were 69.5 as compared with 88.0 in November.

The index of cold storage holdings was slightly lower in December and little change was registered at the first of January.

With the close of the year confidence in the business outlook was somewhat stronger, and wholesale prices were advancing. Apparently a larger proportion of business concerns are paying dividends than a year ago. Retail business seems to be materially better than a year ago. Cold storage stocks are low indicating that supplies are likely to move more rapidly in the future. These are favourable factors.

### ANNUAL AND MONTHLY INDEX NUMBERS OF PRICES AND PRODUCTION COMPUTED BY DOMINION BUREAU OF STATISTICS

| Year | Wholesale Prices 1926 = 100 | | | | Retail prices and cost of services (5) | Production (6) 1926 = 100 | | | |
|---|---|---|---|---|---|---|---|---|---|
| | All commodities (1) | Farm products (2) | Field products (3) | Animal products (4) | | Physical volume of business | Industrial production | Agricultural marketings | Cold Storage holdings |
| 1913.... | 64.0 | 62.6 | 56.4 | 77.0 | 65.4 | .... | .... | .... | .... |
| 1914.... | 65.5 | 69.2 | 64.9 | 79.0 | 66.0 | .... | .... | .... | .... |
| 1915.... | 70.4 | 77.7 | 76.9 | 79.2 | 67.3 | .... | .... | .... | .... |
| 1916.... | 84.3 | 89.7 | 88.4 | 92.3 | 72.5 | .... | .... | .... | .... |
| 1917.... | 114.3 | 130.0 | 134.3 | 119.6 | 85.6 | .... | .... | .... | .... |
| 1918.... | 127.4 | 132.9 | 132.0 | 134.7 | 97.4 | .... | .... | .... | .... |
| 1919.... | 134.0 | 145.5 | 142.4 | 152.5 | 107.2 | 71.3 | 65.5 | 48.1 | 47.1 |
| 1920.... | 155.9 | 161.6 | 166.5 | 149.9 | 124.2 | 75.0 | 69.9 | 52.6 | 94.2 |
| 1921.... | 110.0 | 102.8 | 100.3 | 108.5 | 109.2 | 66.5 | 60.4 | 65.2 | 86.4 |
| 1922.... | 97.3 | 86.7 | 81.3 | 99.1 | 100.0 | 79.1 | 76.9 | 82.6 | 82.6 |
| 1923.... | 98.0 | 79.8 | 73.3 | 95.1 | 100.0 | 85.5 | 83.8 | 91.4 | 87.8 |
| 1924.... | 99.4 | 87.0 | 82.6 | 97.2 | 98.0 | 84.6 | 82.4 | 102.5 | 114.6 |
| 1925.... | 102.6 | 100.4 | 98.1 | 105.7 | 99.3 | 90.9 | 89.7 | 97.2 | 108.9 |
| 1926.... | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| 1927.... | 97.7 | 102.1 | 99.9 | 105.7 | 98.4 | 106.1 | 105.6 | 103.6 | 110.0 |
| 1928.... | 96.4 | 100.7 | 92.6 | 114.3 | 98.9 | 117.3 | 117.8 | 146.7 | 112.8 |
| 1929.... | 95.6 | 100.8 | 93.8 | 112.5 | 99.9 | 125.5 | 127.4 | 101.1 | 109.6 |
| 1930.... | 86.6 | 82.3 | 70.0 | 102.9 | 99.2 | 109.5 | 108.0 | 103.0 | 128.4 |
| 1931.... | 72.2 | 56.3 | 43.6 | 77.6 | 89.6 | 93.5 | 90.4 | 99.0 | 125.7 |
| 1932.... | 66.7 | 48.4 | 41.1 | 60.7 | 81.4 | 78.7 | 74.0 | 114.3 | 120.1 |
| 1933(7). | 67.2 | 51.0 | 45.7 | 60.9 | 78.0 | 79.2 | 76.8 | 105.1 | 115.4 |
| Jan..... | 63.9 | 43.6 | 35.1 | 57.9 | 79.1 | 68.1 | 62.2 | 56.1 | 112.0 |
| Feb..... | 63.6 | 43.0 | 36.0 | 54.7 | 78.4 | 67.0 | 60.9 | 76.5 | 127.6 |
| Mar..... | 64.4 | 44.7 | 38.0 | 56.0 | 77.8 | 68.4 | 62.5 | 129.0 | 135.8 |
| April... | 65.4 | 46.8 | 41.1 | 56.4 | 78.1 | 69.8 | 65.1 | 104.1 | 112.7 |
| May.... | 66.9 | 51.2 | 46.9 | 58.4 | 77.0 | 76.4 | 72.7 | 95.4 | 100.4 |
| June.... | 67.6 | 52.6 | 49.4 | 57.9 | 77.0 | 82.2 | 79.8 | 221.9 | 119.9 |
| July.... | 70.5 | 60.1 | 60.8 | 59.0 | 77.2 | 84.1 | 82.6 | 136.3 | 114.5 |
| Aug..... | 69.4 | 57.0 | 54.9 | 60.5 | 78.6 | 89.8 | 89.5 | 197.2 | 114.2 |
| Sept.... | 68.9 | 54.7 | 49.5 | 63.4 | 78.8 | 90.8 | 90.2 | 101.1 | 115.7 |
| Oct..... | 67.9 | 51.4 | 44.6 | 62.8 | 77.9 | 88.2 | 87.4 | 70.5 | 112.7 |
| Nov.... | 68.7 | 53.8 | 46.7 | 65.8 | 78.1 | 85.5 | 83.9 | 41.8 | 111.1 |
| Dec..... | 69.0 | 53.3 | 45.3 | 66.6 | 78.4 | 86.2 | 85.1 | 30.7 | 107.6 |

1. See Prices and Price Indexes 1913-1928, pp. 19-21, 270-289 and 1913-1932, p. 15.

2. Wholesale prices of Canada products of farm origin only. See Prices and Price Indexes 1913-1931, p. 33, and Monthly Mimeographs 1932 and 1933.

3. Wholesale prices of grains, fruits and vegetables.

4. Wholesale prices of Animals and Animal Procudts.

5. Including foods, rents, fuel, clothing and sundries, See Prices and Price Indexes 1913-1928, pp. 181-185, 290-293. 1926 = 100.

Prices and Price Indexes 1913-1931, pp. 122, and Monthly Mimeographs 1932-1933.

6. Monthly Review of Business Statistics, pp. 8, and Monthly Indexes of the Physical volume of business in Canada, supplement to the Monthly Review of Business Statistics, November, 1932.

7. Preliminary.

It is noticeable that construction remained at low levels in 1933. This has been an unfavourable factor, but there is now prospect of an advance.

*United States.* The Agricultural Situation (January 1) published by the Bureau of Agricultural Economics, Washington, D.C., summarizes the situation as follows: "The reports from the various sections of the country may be summed up as reflecting three general facts, as an outcome of the 1933 season: a somewhat better income from the main cash crops, such as cotton, wheat and potatoes; very short crops and relatively high prices of feed grains, with a resulting difficult winter for many feeders in the North and West; distressingly low prices in the beef cattle, hog, dairy, and poultry industries. So far this winter it appears that the crops are better property than the animals."

*United Kingdom.* The November index of prices of agricultural products was 109 as compared with 107 in October (1911-1913 = 100). The monthly index was 107 in January 1933 and declined until June. Since then, it has been rising steadily and the November index was the high point of the year.

## LA SITUATION ECONOMIQUE

PREPARE PAR LA DIVISION DE L'ECONOMIE AGRICOLE DU MINISTERE DE L'AGRICULTURE, OTTAWA, ET BASE SUR LES DONNEES RECUEILLIES PAR LE BUREAU FEDERAL DE LA STATISTIQUE

Les prix de gros au Canada ont continué leur marche ascensionnelle en décembre. L'indice s'est élevé de 68.7 à 69.0. Les animaux et leurs produits, les fibres, les matières textiles et leurs produits, le bois, les produits du bois et le papier, le fer et ses produits, les métaux non ferreux et leurs produits, et les minéraux non métalliques ont enregistré une hausse, tandis que les produits végétaux, les produits chimiques, et les produits de même nature, étaient en baisse. L'indice préliminaire pour 1933 était de 2.2 points plus élevé que celui de 1932: ce qui est encore plus significatif, c'est la persistance avec laquelle cette fermeté s'est manifestée sur les marchés de gros pendant les derniers mois de l'année dernière.

*Prix du détail.* Répondant à la hausse des prix sur les denrées alimentaires et les vêtements, l'indice des prix du détail qui était à 78.1 en novembre s'est élevé à 78.4 en décembre. Il est à noter sous ce rapport qu'il y a eu en général amélioration dans le commerce du détail pendant les cinq derniers mois de 1933 par comparaison aux mêmes mois en 1932. Ceci indique que la confiance renaît et que le pouvoir d'achat augmente.

*Embauchage.* La situation du travail continue à s'améliorer. L'indice au 1er janvier 1934 était de 95.0 contre 91.8 au commencement de décembre. Le nombre actuel d'ouvriers employés était un peu moins élevé qu'au 1er décembre, mais la baisse saisonnière habituelle a été beaucoup moins forte que d'habitude, et c'est pourquoi l'indice réglé est plus élevé.

*Volume physique des affaires.* L'indice du volume physique des affaires, qui était à 85.5 en novembre est passé à 86.2 en décembre. C'est là 13.6 points de plus que l'indice de décembre 1932. La production industrielle était de 17.4 points supérieure à l'indice de décembre 1932. Au cours du dernier mois, l'indice des industries manufacturières s'est relevé de 2.4 points. La production minérale était aussi plus forte. La production du fer et de l'acier a beaucoup augmenté, mais le bâtiment était encore bas. Il est intéressant de noter que l'indice du volume physique des affaires, qui était de 125 en 1929, est tombé à 78.7 en 1932, et remonté à 79.2 en 1933. Ceci n'indique guère cependant jusqu'à quel point la diminution du chiffre des affaires a été enrayée mais le fait que cet indice n'est pas descendu au-dessous de 82 depuis le mois de mai est un signe éloquent d'amélioration. Cette augmentation dans le volume physique des affaires est peut-être le meilleur indice des conditions que l'on puisse trouver, si un seul indice doit servir de guide. Les prix de gros et le volume des affaires paraissent avoir tous deux la même marche ascensionnelle. Il est évident qu'il existe des relations entre les deux.

*Produits agricoles.* L'indice des produits agricoles canadiens avait baissé d'une fraction en décembre à cause d'une baisse assez prononcée dans l'indice des produits des champs. Les prix du grain étaient en général plus faibles, faisant contre-poids à une hausse dans l'indice des produits animaux.

Les ventes agricoles ont atteint un bas niveau en décembre, l'indice est tombé à 30.7. L'indice du grain était à 24.7 et l'indice des produits animaux à 57.5. Les ventes de porcs étaient à 69.5, contre 88.0 en novembre.

L'indice des produits frigorifiés était légèrement plus bas en décembre et il n'y a eu que peu de changement au 1er janvier.

Vers la fin de l'année, la confiance dans l'industrie paraissait renaître, les prix de gros montaient. Le nombre de maisons de commerce qui paient des dividendes est plus considérable que l'année dernière. Le commerce du détail paraît être dans une bien meilleure situation qu'il y a un an. Les stocks en entrepôts froids sont peu abondants, ce qui indique que les approvisionnements s'écouleront plus rapidement à l'avenir. Ce sont là des facteurs favorables. Il est à noter cependant que le bâtiment est resté à un faible niveau en 1933, et la situation générale en souffre mais l'on prévoit maintenant une amélioration.

*Etats-Unis.* La situation agricole (1er janvier) publiée par le Bureau de l'économie agricole, Washington, D.C., résume la situation comme suit: "Trois faits généraux, résultant de la saison de 1933, se dégagent des rapports reçus des différentes parties du pays: rendement des principales récoltes pour la vente en nature, comme le coton, le blé et les pommes de terre, un peu plus fort, très faibles récoltes et prix relativement élevés pour les grains à bétail, et hiver pénible pour beaucoup de nourrisseurs du Nord et de l'Ouest; prix d'une faiblesse désespérante pour les industries du boeuf, du porc, de la vache laitière et des volailles. Jusqu'ici cet hiver, il semble que les récoltes sont plus avantageuses que les animaux."

*Royaume-Uni.* L'indice de novembre des prix des produits agricoles était de 109 contre 107 en octobre (1911-1913 = 100). L'indice mensuel qui était de 107 en janvier 1933 a baissé jusqu'en juin. Il s'est relevé rapidement depuis lors et l'indice de novembre était le point le plus haut de l'année.

## RESUME DES ARTICLES PUBLIES EN ANGLAIS DANS CE NUMERO

### La situation de l'agriculture dans la vie economique du Canada. T. W. Grindley, Bureau Fédéral de la Statistique, Ottawa, Ont.

L'auteur montre le sérieux de la situation agricole au Canada. Les chiffres qu'il donne démontrent la difficulté et même l'imposibilité qu'il y a à rembourser des dettes contractées avant 1929, commencement de la déflation, avec un revenu qui a été réduit depuis de façon considérable. La réduction des coûts de production et des dépenses courantes constituent le premier pas à faire pour parer à la dépression, mais de telles mesures doivent nécessairement être completées par une liquidation des dettes et une amélioration des prix. Des restrictions sur les saisies seront également utiles. Elles préviendront le désespoir, l'éviction et l'abandonnement en masse des exploitations agricoles.

Il est cependant possible d'accorder trop d'importance aux dangers de la situation actuelle. La position du cultivateur est soumise à des fluctuations soudaines et rapides. Les prix des denrées agricoles sont généralement les premiers à réagir et à remonter après une dépression. Les divers facteurs qui amènent la déflation des revenus comportent généralement leurs propres correctifs. La sévérité des ajustements nécessaires en matière de réduction de dépenses mesure les économies et les bénéfices qui seront réalisés quand les prix commenceront à remonter. La rapidité avec laquelle se terminera la dépression dépendra ainsi de la réduction des dépenses, puisque les prix en hausse deviendront profitables d'autant plus tôt que les dépenses auront été réduites davantage. La fin de la dépression agricole actuelle ne sera pas aussi nette qu'en 1924. Les espérances de la première moitié de 1933 ont été en partie détruites. On avait pris pour la guérison depuis si longtemps attendue ce qui n'était qu'une simple spéculation sur les résultats de la déflation. Une partie de l'avance dans les prix a cependant été retenue. Le mouvement à la hausse peut être erratique, mais il y a des signes indubitables qu'il a réellement commencé.

# LES LIVRES

## LE PREMIER VOLUME D'UNE ENCYCLOPEDIE AGRICOLE

L'Ecole Supérieure d'Agriculture, Ste. Anne de la Pocatière, a depuis sa fondation en 1859 toujours occupée une place prépondérante dans les destinées agricoles du Canada-français, tant par les mouvements et les politiques d'organisation agricoles qu'elle a dirigés, les programmes d'action qu'elle a conçus, que par ses professeurs qui ont représenté les intérêts des cultivateurs aux Parlements de Québec et d'Ottawa. C'est pour pousser plus loin son travail d'action, envers une vulgarisation et une diffusion encore plus générales de la science agricole, qu'elle a crû devoir assumer la tâche de préparer ce nouveau Manuel d'Agriculture. C'était pour répondre à un besoin urgent et aussi parce que la publication d'un tel volume avait été demandée avec instances, surtout en ces derniers temps.

Tandis qu'en France l'on connait *l'Encyclopédie Agricole* publiée par un comité d'ingénieurs-agronomes, éditée par J. B. Baillière & fils, et qu'aux Etats-Unis, l'on a la *Série des Manuels ruraux* (Rural text-book series) éditée par L. H. Bailey, nous n'avions chez nous aucun travail de similaire importance. Il convenait qu'au Canada-français la publication d'un *Manuel complet d'Agriculture* en trois volumes soit entreprise par la plus ancienne Institution agricole au pays.

En parcourant le tome premier, *Les Champs*, l'on ne tarde pas à se rendre compte qu'un tel volume représente, de la part du groupe de professeurs qui ont collaboré à sa rédaction, une somme de travail considérable, et comme le dit si justement Son Emminence le Cardinal Villeneuve dans sa lettre d'approbation ". . . . . qu'il marque un bel effort du personnel enseignant de notre Ecole d'Agriculture pour diffuser plus largement encore les bienfaits de la science agricole".

*Les Champs* n'est pas un simple manuel rempli de formules techniques, c'est un traité complet du sol et de la production des récoltes. Rédigé en termes compréhensifs, en phrases claires et consices, pleines de sens et d'enseignement, suffisamment pourvu d'illustrations expliquant les points essentiels du texte, il met successivement sous les yeux du lecteur l'étude du sol, ses qualités, ses défauts, les amendements, les façons culturales etc., etc. Au cours de ses six cent trente pages, ce premier volume expose la relation entre le sol et les plantes et indique les principes généraux d'amélioration. Les maladies des plantes, les insectes et les mauvaises herbes sont tour à tour étudiés et les moyens de protection et de destruction clairement indiqués. C'est avant tout un livre essentiellement pratique, destiné au grand public agricole, aux cultivateurs. "Un dictionnaire d'Agriculture que ce volume *Les Champs*", me disait dernièrement un de mes bons amis-cultivateur, résumant ainsi son appréciation.

C'est l'aide-mémoire réclamé par l'agronome soucieux de pouvoir toujours donner en tout et pour tout une réponse juste et précise. C'est le livre tout désigné pour les curés ruraux, les écoles moyennes d'agriculture, les cours abrégés, les cercles agricoles, les opérateurs de fermes et de champs de démonstration, les cercles de jeunes, les jardins scolaires, etc. Ce devrait être aussi la plus importante partie du bagage d'un colon.

C'est un traité qui offre des suggestions, des méthodes d'amélioration réalisables sans de grands déboursés. C'est un livre au point. On dit que les bons livres font leur chemin. *Les Champs* et les deux volumes qui le suivront iront plus loin; ils feront époque dans notre histoire agricole au Canada-français.

—Georges Gilbert.

## NOTES AND NEWS

### WHAT IS AGRICULTURE WORTH TO CANADA?

The main theme of most of the oratory and editorial comment produced for rural consumption in Canada is, "the farmer—the backbone of the nation!" Commerce and industry accompany with the chant, "when the farmer is prosperous, business is good." The same idea is to be found in all young and growing countries wherein agricultural expansion on a large scale has taken place during the last century. The United States had achieved what was thought to be prosperity founded on a steadily expanding industrial system, but it has been pointed out by some of those who are responsible for framing the present farm programme that agriculture was on a downward spiral even during the time when the purchasing power of the American public was at its peak. Partly because of the plight of the farmer, the depression is said to be more severe in the United States than in Canada. These things are all "said to be" so, and most of the time we accept such statements as axiomatic. It is well, however, to probe a little deeper. We in Canada are subject to many of the same forces of western civilization which manifest themselves to an advanced degree in the United States. But economic conditions are by no means the same in the two countries.

The position of agriculture in the economic life of Canada is presented in this issue very clearly by Dr. T. W. Grindley of the Dominion Bureau of Statistics. The stabilizing effect of Canadian agriculture on our economic life, and the dependence of Canadian agriculture on world markets are points with which all technical agriculturists should familiarize themselves, and we feel that Dr. Grindley has assembled a portion of the information from the last census in a very comprehensive and useful manner.

### C.S.T.A. AND C.S.G.A. CONVENTIONS IN QUEBEC

During the past month plans for holding the annual C.S.T.A. and C.S.G.A. conventions have developed rapidly. A preliminary meeting was held at Macdonald College on January 18th, followed by a meeting with officials of the Quebec Department of Agriculture at Quebec on February 6.

To economize in time and expense, both organizations have reduced the length of their conventions to a minuimm, and have arranged to meet at the same time for certain sessions. It is expected that the Plant Breeders section of the C.S.G.A. will meet on Friday and Saturday, June 22 and 23 at Macdonald College. On Monday, Tuesday, and Wednesday, June 25 to 26, both organizations, along with affiliated groups and societies, will meet at Macdonald College.

An interesting programme is in the process of development. The various groups and societies concerned are planning for two or three half-day sessions of intensive study of their specialties. Programmes for the open sessions of the C.S.T.A. will probably center around the policy of the Society under present conditions, on the present economic situation, and on educational methods in the Province of Quebec.

In connection with the latter subject, a tour of the province has been planned to allow members of the C.S.T.A. to study the various institutions and extension methods now functioning. On Thursday, June 27, the convention will visit the Oka Agricultural Institute at La Trappe, a short distance from Macdonald College. This institution, affiliated with the University of Montreal, is one of the two agricultural colleges in Quebec. Extensive additions have been made to the buildings and equipment since the C.S.G.A. convention was held there in 1926. On Friday, June 28th, the party will leave for Quebec City, stopping at Deschambault in the afternoon. The farm at Deschambault, under the direction of S. J. Chagnon, is a resident vocational institution for farm boys. Hundreds of farm boys have attended this school to learn various farm operations and to take short-courses in various subjects. From Deschambault the party will motor to Quebec for the night, and on Saturday morning will hold a C.S.T.A. session. Week-end tours will be arranged to historic and scenic spots. A visit to the Agricultural School at Ste. Anne de la Pocatière will be arranged for those driving east, and a tour to points in the Eastern Townships will be arranged for those returning to Ottawa and points west.

Arrangements for both the C.S.T.A. and C.S.G.A. have been placed in the hands of one committee with two vice-chairmen, one to look after each organization. This committee includes representatives from all institutions and organizations involved, but lack of space prevents us from including more than the executive of the general committee and the chairmen of sub-committees.

### GENERAL CONVENTION COMMITTEE:

*Honorary Chairman:* Hon. Dr. Adelard Godbout, Minister of Agriculture for Quebec and President, C.S.T.A.
*Chairman:* J. F. Snell, Acting Dean, Macdonald College.
*Associate Chairman:* Rev. Fr. Leopold, Director, Oka Agricultural Institute and Vice-President, C.S.T.A.
*Vice-Chairman:* Prof. R. Summerby, Macdonald College, President, C.S.G.A.
" " Mr. L. H. Hamilton, President, Macdonald College Local, C.S.T.A.
*Secretary:* Mr. A. J. G. Maw, Macdonald College, Secretary, Convention Committee.

### SUB-COMMITTEES:

*Programme:* L. C. Raymond, Chairman
*Accommodation:* E. W. Crampton, Chairman
*Transportation:* A. R. Ness, Chairman
*Entertainment:* W. A. Maw, Chairman
*Publicity:* L. C. McOuat, Chairman

## NEWS ITEMS

G. Boucher (Laval '33) of Saint-Philippe de Néri, P.Q., is now doing post-graduate work in economics at the Ontario Agricultural College. His address is Department of Economics, Ontario Agricultural College, Guelph, Ont.

C. A. Eaves (McGill '32) formerly of the Horticultural Division, Central Experimental Farm, Ottawa, is taking post-graduate work at Cambridge University. Mr. Eaves was the recipient of a scholarship from the I.O.D.E. and is carrying on work in cold storage of apples.

The sympathy of members of the Society is extended to Dr. H. B. Sommerfeld and his son on the death of Mrs. Sommerfeld at Yorkton, Saskatchewan, on December 20th.

The sympathy of members of the Society is also extended to Professor R. Summerby of Macdonald College on the recent death of his mother.

## NEW MEMBERS

The following members have been received since December 1, 1933:

R. D. Bird (Manitoba 1924, B.Sc.), Brandon, Man.
A. J. Boudreau (Laval 1932, B.S.A.), Inverness, N.S.
O. G. Caldwell (Manitoba 1932, B.S.A.), Winnipeg, Man.
C. A. Eaves (McGill 1932, B.S.A.), Cambridge, England.
Ernest Giasson (Laval 1932, B.S.A.), Ste-Martine, P.Q.
P. Lagloire (Montreal 1932, B.A.), Quebec, P.Q.
S. J. MacKinnon (N. S. Agricultural College), Mabou, N.S.
R. J. MacSween (N. S. Agricultural College), Antigonish, N.S.
Maurice Proulx (Laval 1931, B.S.A.), Ithaca, N.Y.
A. Touzain (Laval 1932, B.S.A.), Quebec, P.Q.
T. Uyeda (British Columbia 1933, B.S.A.), Vancouver, B.C.

SCIENTIFIC AGRICULTURE

Vol. XIV MARCH, 1934 No. 7

# PHILOSOPHY FROM AN AGRICULTURIST[1]

E. A. Howes[2]

*University of Alberta, Edmonton, Alta., Canada.*

Mr. Chairman and gentlemen:

I wish, at the outset, to express my appreciation of the kindly courtesy on the part of the O.A.C. Alumnae and the C.S.T.A. in asking me once more to be the guest speaker at their annual banquet. I am sincerely sorry that our University President, Dr. R. C. Wallace, was unable to accept your invitation to be your speaker at this event and he asked me to convey to you his regrets, also his greetings and best wishes. I wish to offer my regrets because I would much prefer to have our President speak to you this evening. We are rather proud of our President. However, even if I am an afterthought, I am consoled by the fact that another great person in the world's history was only an after-thought. I refer to Mother Eve.

At the outset also, I should like to pay my tribute once more to that great organization, the C.S.T.A., and more particularly to-night to your Locals represented here. My now almost patriarchal connection with the C.S.T.A. renders it unnecessary for me to more than mention the Society in passing. When I pay my tribute to the O.A.C. I wish again to emphasize my deep sense of gratitude to that institution not only for the impetus it gave me in my life's work but perhaps chiefly because of the happy hours I spent on College Heights and the many friends made at that time—the kind of friends that stick by you. In that connection I want to mention the class of 1911, which in spite of possible contradiction, I do maintain was and is the outstanding year in the class history of the College. Take a look over what its graduates are doing to-day if you doubt my statement.

I am planning this evening, with your kind tolerance, to indulge in some homely philosophy, if one may use so ambitious a term, in regard to western agriculture and agriculturists. I have in vivid recollection the splendid address given by Dr. Barton a few years ago in which he dealt intimately with the educational side of agriculture. I trust he will not forget what he then said now that he has gone to that "seat of iniquity" at Ottawa. I understand that Dean Shaw two years ago talked to you about certain agricultural conditions in the West. He and I are rather close together, geographically and otherwise, and I am probably in accord with all that he said, but I wish to avoid covering any part of the same field. In my talk to-night I shall have in mind our people and shall mention conditions and problems only as they affect our people as they "live, move and have their being".

It is inevitable that in all that I have to say with regard to western conditions and people, I shall have in the foreground of my thoughts the young people. As a matter of hard fact we older people are not nearly as important as we try to make ourselves believe. Our wisdom and foresight, developed by years of experience, are only important in so far as we use them to shape better facilities for those who are coming after us to do our work just a little better than our performances indicate. That is our great privilege.

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[1] Address delivered at the annual Ontario O.A.C. Alumni Association—C.S.T.A. Banquet, Royal York Hotel, Toronto, Friday, November 24, 1933.

[2] Dean, Faculty of Agriculture, University of Alberta, Edmonton, Alta., Canada, and President of the C.S.T.A. 1925-26.

I submit that if we are going to exert the influence just indicated we must devote ourselves to the task of showing the young and coming agriculturists that there is still a vital challenge in agriculture. It may be true that the day of the sod hut in the West is gone; that the work of the range is more and more shaping itself along less picturesque lines; that the Indian has largely disappeared and anyway does not represent thrill and adventure any more. Indeed, many of the things that took our young people West, challenges of adventure, if you please, no longer beckon. I want, however, to indicate in the West a definite challenge to those who are up and coming in the youth of the land, a challenge which will call for all of the fortitude, all of the vision and all of the action which we have ascribed in the past to pioneers, and I really think that we should try to present these fields of possible activity in a way that shall indicate the fact that there are still many dragons to conquer, wrongs to redress and romantic episodes in the offing if they will only look for these things. And now, having indicated the spirit in which I wisn to consider the problems before us, I shall offer my brief homely comments upon some of the fields that are challenging us in our building up a country which we have "overrun but not yet occupied".

## I. Agricultural Economics

I take this first because I know least about it and not many of you know much more. Perhaps you will say "surely there are enough talking in this field at present"; and I would say, "more than enough". I am certainly not pleading for more people to air their views in regard to our economics. I am really going to plead for a smaller number who shall take a much longer time in which to inform themselves. This is not peculiarly a western problem I notice and indeed some of your eastern authorities are apparently ready to settle the question for us quite promptly.

Of course I do not refer to the great body of the people, who, undoubtedly, should take an intelligent interest in the economic factors that affect their lives, but when it comes to special diagnoses there are not so many running loose in Canada who are competent to pass expert judgment in regard to our economic problems. Let me add that I am always pleading for more study and less talk. I am sure you will recognize the great field for work in agricultural economics in Eastern Canada as well as Western, so I will not labour the question.

I have voiced my confession of faith because I am tired to death of the demagogic soap-box specialist in this day when we have enough real trouble. We have no right to demand infallibility, but we certainly have a right to be delivered from quackery, and to this end I would earnestly advocate that there should be a constant seeking after the few who are so mentally endowed that it is worth their while, and worth the while of their fellow men, that they shall be given every opportunity to become high-class specialists in dealing with problems that you and I have not the time and training to diagnose.

In connection with the foregoing comment I should like to record my satisfaction and encouragement in the step taken by the management of *Scientific Agriculture* as indicated in the October issue. Here is presented quarterly, *The Economic Annalist,* a review of agricultural business. Then too, monthly, will be furnished statistical material that should be of outstanding importance to all of us who are interested in technical agriculture. In doing this *Scientific Agriculture* is performing a valuable and timely service.

## II. Co-operation

In this case I am approaching the subject with a certain hesitancy. The term co-operation has been tossed about from one to another and in some cases has so developed into a sort of verbal band-wagon, that it is only a sense of duty that makes me feel like offering my contribution.

Let me say at the outset that I firmly believe in co-operation, but if you come right back at me and ask me what I mean by co-operation, I shall pick my words very carefully. Four or five years ago, in my first C.S.T.A. report on Agricultural Policies, I stated "co-operation is an over-worked term for for a sometimes nebulous idea". It is quite probable that I was too severe in my criticism, but I still maintain that I defined something that was well worth thinking about. I mean that one can use a term in such a glib and off-hand way that we can render it meaningless by too much repetition. In the second place, I think I was correct in saying that a lot of the people who talked about co-operation had rather ill-formed ideas about the scope and possibilities of the principle they were discussing.

Now, I am not going to talk about certain factors of co-operative effort in our West that have attracted the attention of the world. I am not going to discuss with you the status of the several pools, nor shall I discuss particularly the matter of purchasing agencies. I am well aware that I am talking to an audience with mixed opinions and your opinion is just as good as my own. I want to discuss the problem from an angle that is not so very often recognized. Even supposing our pools and our central purchasing agencies were functioning to perfection, or even if they had all failed, either case would not affect the argument I wish to bring forth.

To me co-operation is a spirit. In some countries it would be hailed almost as a religion. It is of the heart as well as of the head, and therein lies the grand opportunity for the young people who are going out in the next decade to face the world. I am hoping that some of our young knights, going out to do worthy deeds, will see in this great field of co-operative effort, a chance to leave their mark on Time's record.

Co-operative effort presupposes a pooling of effort, at times, of resources, and the pooling of thought, and this presupposes that the individuals so co-operating have each something to contribute to this pool, and I do not mean wheat pool or any special institution. Therein lies one of our great difficulties. Suppose we have two farmers living side by side under fairly similar conditions of climate and soil. You know as well as I do that one of them may show evidences of thrift, of culture, of happiness, while it is possible that his neighbor will fall far short of showing these evidences. I leave it to you to say which of these two would shout the louder for co-operation if some pooling of effort were under discussion. I submit that it would be the man who had the least to pool. This is not a condemnation of co-operation, but indicates one of its difficulties. However, that is not my main point. What I wish to propose to you is that often when we in the West have been advocating co-operation, what we sometimes had in mind was the effect of co-operation rather than the foundational causes.

I wish to say, in all seriousness, that it is my contention that co-operative effort based only on a knowledge of the alleged mechanics of co-operation, or based upon the desire for personal gain, is starting off with a tremendous handicap. It is my contention also that co-operative effort should be a builder of character and, as well, an evidence of character. So I say that we cannot begin too soon in our educational institutions to quietly and in a simple way build up a concept, on the part of the young people, that co-operation means individuals working together for the good of the whole body of our people, with a sense that the highest ideal is, " What can I contribute? " not, "What can I get out of this?". I am not at all making light of the mechanics of co-operation, of co-operative buying and selling agencies, because if the proper spirit and character is there, the very pooling of efforts and resources is bound to find its implement in some such way. But again I say that these are the effects and not the causes, nor necessarily always inspired by the spirit of co-operation. What I am trying to emphasize is that co-operation is a vastly greater thing than a group of farmers, or a group of labourers, or a group of commercial men, banding together to secure cheaper purchase or higher prices. This in itself may be effort worth while, but again I say that unless it is based upon unselfishness, upon thought for the other fellow, it is running a very fair chance, even in a material sense, of failure to accomplish that which was intended.

## III. PRODUCTION AND MARKETING

How often one has heard during the past few years, the statement "we have solved the problems of production but we have paid little or no attention to the problems of marketing". Every time I have had the opportunity I have raised my voice in protest against this sweeping statement simply because it is not according to fact. That we have not paid enough attention to the machinery of marketing, I am quite ready to agree; also that one of our major enterprises should always be the proper distribution of our products; but when people say that we have solved the problems of production, I must take exception in no uncertain terms. The fact of the matter is that we, in this far-flung country of ours, are mere children in the matter of production. If there has been over-production quite recently, and this is still regarded as debatable, it is absolutely no proof that we have solved the problems of production. Moreover, it must not be forgotten that production is an integral part of a sound marketing system and cannot be so divorced. They are as inseparable as Mutt and Jeff, or ham and eggs,—indeed more so.

I said at a C.S.T.A. Convention, as far as I can recollect, "If we can train our people to produce the right thing at the right time and in the right way, we shall have taken care of the biggest problem in marketing". You may think that this is an extreme statement, but it was made after long and careful thought and is not in the least intended to minimize the importance of a study of the machinery of marketing. Let us analyze my statement. Have we always produced the right product? The answer is most emphatically, "No!" Was the great concentration on wheat all over the West producing the right product? Not in some districts, by a big margin. Speaking of wheat again, was it produced at the right time? Again, not always, or the quality would have been better. Perhaps we did our best in so far as we had light. Was it produced in the right way? Not altogether, when we consider the multiplicity of varieties that have flooded the market in recent years, inevitably detrimental to the quality of our product, and quality is the one asset on which we have to bank in a world-wide striving for wheat markets. I might also add that there were areas broken to wheat that should, by all means, have been left to grass, and there were areas cut by combine that should not have been so handled.

When we come to the realm of livestock products we have still less to show for our work in producing the right product at the right time and in the right way. I must not labour the question further at this time, but I hope people will think it over seriously, each in terms of his own locality.

## IV. Mechanization

Some years ago—not so very many—I took a ride in the first automobile that came to the city of Ottawa. Five of us with more money than judgment, and not much of either, chartered this famous machine, along with its driver, to take us to the Fair at Richmond, some twenty miles distant. The machine had a dash-board like the buggy—there may even have been a whip socket. At any rate, except for the driving wheel, the front part was built after the style of the old phaeton. The large section was arranged like the hotel bus, with two longitudinal seats facing each other and the passengers entered from the rear by using a set of bus steps. Over the top was a square cover, again like the old phaeton top, and there was no side protection. The drive wheels were propelled by an outside chain drive, after the manner of the bicycle.

As we groaned and ground our way over the macadamized road, we could not keep out of our own dust and all the dogs in the country turned out to bark at us. When we reached the fair ground we excited more active attention than is accorded the flying machine to-day. The fair management asked us to drive around the race-track. We drove around two or three times before all of the people, crowded on wagons, fence rails, grandstand and wherever a place of vantage was obtainable. I elected to ride on the step at the back of the car and in making the circuit I harangued the crowd, as I distinctly remember, to the effect that they were looking at something that was going to change the whole world for us. Had I died that day I should surely have been put in the same box-stall as the prophets.

That was twenty-eight years ago this fall. If anyone that day had ventured to whisper even a suggestion of the change that has taken place in that period, he would have been met with pity; yet the crude machine in which we rode was the beginning of something that was to greatly influence our civilization.

The foregoing reminiscent paragraphs are simply introductory in their intent. Twenty-eight years is quite a space in one man's life, but what an infinitesimal fraction in the life of the race! It is not my intention to dwell on the evolution of the automobile, important and far-reaching as the story would necessarily be, but to deal with another phase of the great change in our civilization; a change that was heralded by the advent of the automobile; I refer to the mechanization of the agricultural life of our people.

In a few years the driving horse has practically disappeared from the farms of our country, not because the older people willed it, but because the younger, and to a lesser extent the older people, having once experienced the speed of the automobile, were not to be easily reconciled to the comparatively plodding movement of the driving horse. Yet the old horse and buggy had its day and in bidding it good-bye let us do it the justice to record the interrogation, "Are the people happier than they were twenty-five years ago?" The young people of to-day need not feel any sense of superiority; the only difference is that the driver sits on the left-hand side of the vehicle now, and the prevalent parked automobile on a summer night is only the present-day manifestation of the old way of a man with a maid, when in another age the driver simply wrapped the reins around the whip stock and a properly trained horse did not need to be parked.

With the adoption of the automobile by the younger generation it was inevitable that these younger fellows should become machine-conscious rather than horse-conscious. Concurrently with this change, tractors were emerging from the steam age to the age of gasoline. It needs no stretch of the imagination to indicate how the farm boy just naturally took to the handling of a tractor, being used to the problems involved in the gasoline engine.

Now, there are probably some of you here who have heard my confession of faith in regard to the place of farm mechanization, or perhaps you have read it, because I have spoken in no uncertain terms at many meetings, and my talks were somewhat widely printed. In a word, I have pleaded for a sane analysis in regard to the place of new inventions in our farm practices. I think I was guarded about making sweeping statements because of the great variety of conditions existing in our West, but I have been somewhat concerned that so many speakers and writers (strange to say many of these came from the East) were bound to drive us into some rather indefinite grandiose scheme of mammoth farming that would have as its object growing wheat at a minimum cost per bushel, with a great lessening of labour and the days would all be sunny. Right here I would like to interject a statement that part of my impatience is due to a realization of the fact that the farmer is over-advised. If I allowed myself, I should probably speak with some heat about the number of untrained men who feel that they can advise in regard to the technique of agriculture. It is hardly fair, when we train men for this purpose, that the landscape should be cluttered up with this type of adviser, who has at least one gift—that he is able to attract attention.

I note that there has been a tendency to sneer because there has been a reaction toward diversified farming and it is pointed out, quite truthfully, that livestock is also low in the market at the present time, therefore, "Why advocate livestock?" Well, I should like to point out that the very strong reaction toward the raising of livestock in most of the areas in the West has not been with the idea of making some quick money but because in and with that type of effort lies a reaction toward providing reasonable maintenance upon the farm. I should like to suggest that probably very little of this swing back to livestock was due to advice from the outside.

Before leaving this topic I should like to submit that in a large part of our West the farmers should seriously ponder whether the saving of a little labour will justify their doing away altogether with horses. I may be a little prejudiced in the matter, but the fact remains that a very large number of farmers have, under present conditions, returned to the use of horses, for reasons which are obvious, and there is not a doubt that the farmer who had the odd horse on the premises lately very often considered himself as lucky. Frankly, in many areas in our West the ideal situation would be the employment of both the horse and mechanical power, one being the complement of the other; he who advocates the opposite is either decidedly an enthusiast for the mechanical age or perhaps is just a band-wagon addict who will have some other slogan shortly.

## V. Sweeping Statements

I hope that the young man of the next decade will not be given to sweeping statements. To thoughtful men it must appear that in the West we have been great sinners in this respect, or the cause of great sinning at least. I am not going to speak of this as it affects politics or economics, but I would like to confine myself to its relation to farm practices. Let me use a concrete example and you can apply the particular as you will. How often have we heard and read within the last three years, a solution, or solutions, of our soil difficulties? It has been done: "In the West they should do this", or "In Saskatchewan they should do something else". Now in all common sense how can any man in dealing with this far-flung country of ours, attempt to lay down a rule? Here I am speaking about something of which I am confident. Beginning somewhere about 1919 we began a thorough-going, systematic soil survey of the province of Alberta. Following the blocks marked out by the Dominion Department of Interior, we took a certain sheet each year. This was thoroughly surveyed by men who knew their job. Maps were built up from the findings and observations; a map for each sheet and a report for each sheet surveyed to date was printed. We began our work in the southern part of the province, covering the MacLeod Sheet, Medicine Hat Sheet and others. Then, due to the fact that so much attention was being attracted to the North, and later due to the fact of the possibility, or probability, of our taking over our natural resources, our field gangs were switched to the north country. That is all the explanation I need give. What I want to say is that anyone among you who would examine our maps to-day, would be impressed, first of all, with the tremendous variation in the soil conditions obtaining in large districts. He who would examine these must come away firmly convinced that any sweeping statement as to soil conditions of the Province of Alberta is ridiculous and presumptuous.

## VI. The In-and-Outer

The young farmer of tomorrow will, I hope, have ceased to be an in-and-outer. You know what I mean—a man who, when pork is high, rushes into pigs, and then when the horizon is darkened with pigs and the price is going down, is anxiously looking for some other chance to plunge. If wheat is high, he breaks up land that should be in pasture and that should never have been broken perhaps, and then when the wheat market slumps, well, he is ready to try something else. That man is not a farmer; he is only masquerading as one. I hope that the hypothetical young man that we are considering will save and invest soundly his profit when prices are good and that he will know better than to throw up his hands and quit because prices have gone down.

## VII. The So-Called Foreigner

A great problem in the West is the assimilation of the so-called foreign peoples in a way that should be best for the future of that part of Canada. I am not at all pessimistic about the possibilities in this field. We have in our University many of the children of immigrants, and their record is one of which they well may be proud. A great body of these people are generally spoken of as Ukrainians and they have brought to the West an industry and thrift which the rest of us might well strive to imitate. They have brought to us also their own culture as exemplified in their handicraft and their music. I have very grave doubts as to whether you and I, if transported to a new country, could show such qualities of adaptation as evidenced by these people. There is a great field for serious thought that the assimilation, which will take place anyway, shall take place in the best way.

## VIII. Self-Pity

One more thought and I am through. I am much concerned that there appears to be a growing tendency among adults to make young people of to-day sorry for themselves. It is my opinion that this is deplorable. It is a fact that times are difficult and that opportunities for employment are limited, but I would suggest that these people study history. Even if they are sincerely convinced that they, in their generation, have made a mess of things, let them put up to the young people the challenge to go in and do better if they can. The worst thing they can bequeath to the young people is a tendency to be sorry for themselves. I lived amid the depression of the early nineties when the scrub-brush was full of pot gangs and there was no attempt at organized relief. I slept beside straw-stacks and asked for something to eat and, to top it all, travelled part way East with Coxey's army—but I did not feel sorry for myself. If by waving a fairy wand I could trade places with any young man of to-day I would take his youth and let him have my job. I would like to be a young fellow again.

# A COMPARISON OF TEMPERATURES IN AIR AND AT VARIOUS DEPTHS IN A LIGHT SANDY SOIL IN SOUTHERN ONTARIO[1]

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[Received for publication November 30, 1933]

The soil concerned in this investigation is classified as Plainfield sand and is typical of a considerable area planted to orchards in Norfolk County. In the area where the records were taken the humus layer is from 2 to 5 inches in depth, succeeded by yellow sand which continues to a depth of approximately 6 feet. At this point grey sand appears and is continuous to depths of from 8 to 11 feet. The organic matter content of the surface soil was less than 2% as determined by analysis. The ground cover consisted of nothing in April and May with from 1 to 4 tons green weight per acre for the remainder of the growing season. The winter cover was the dried residue of the summer crop, which was made up of about one-half oats and one-half various weeds.

Weekly recording thermographs of the two-pen type, with mercury in steel cables were used, with the cables sheathed in lead to prevent damage from climatic or soil conditions. The drum was driven by an eight-day clock which was checked when the charts were changed. The instruments were compared for temperature and lag with a standardized thermometer, over more than the range required, both before and after the period of use, and were found to be accurate to within 1°F. There was no lag in temperature response that would materially influence the accuracy of the results as presented. The instruments were located in an apple orchard, between the tree rows, and enclosed in ventilated shelters similar to those in use by the meteorological service. The nearest trees were 15 feet each way and approximately southwest and northeast from the instrument shelter. Trees on the diagonal, north, east, south and west were 33.5 feet distant.

The bulbs were inserted in the side of a trench, at the required depth, and the trench was filled in and left undisturbed for the two years' test. The unusual uniformity of the soil rendered the filling of the trench a simple operation. The air temperature bulb was held in place just below the floor of the instrument shelter. This seemed to offer the optimum protection

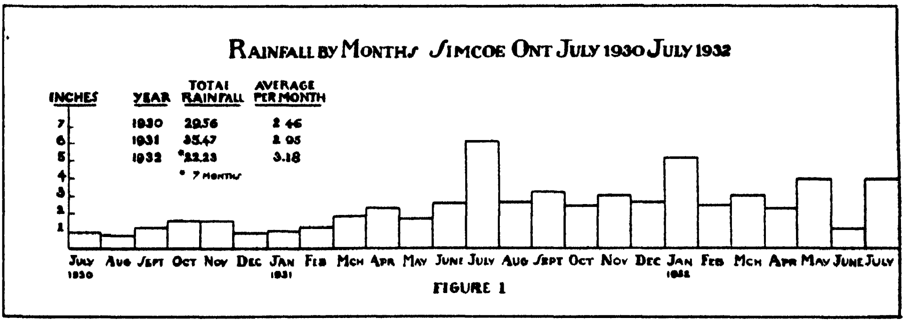

FIGURE 1

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[1] Publication authorized by the President

[2] Assistant Professor of Horticulture, Assistant Professor of Chemistry, and Assistant in Horticulture respectively.

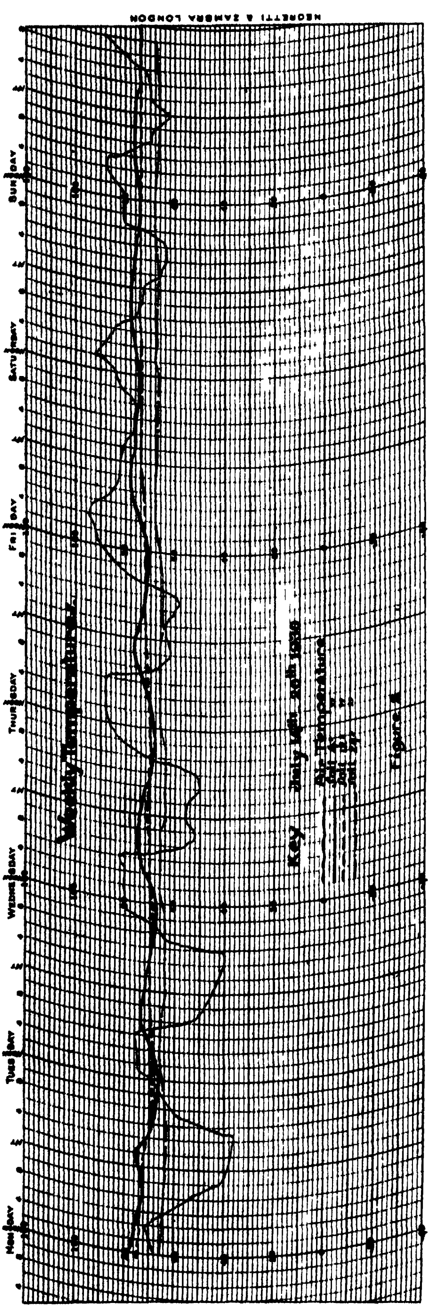

Figure 2

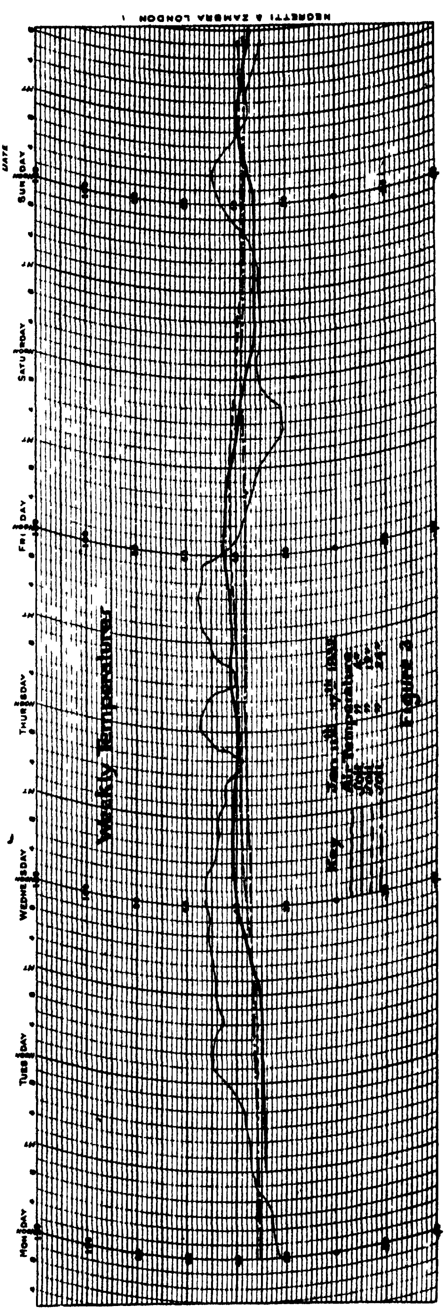

Figure 3

from the rays of the sun and, at the same time, permit exposure to free air circulation.

The period of temperature study was from July 9, 1930, until July 10, 1932. Temperatures are in Farenheit in all cases and were recorded for air and 4, 12 and 24 inch soil depths.

Precipitation records, obtained through the kindness of Dr. W. E. W. Jackson, Assistant Director of the Meteorological Service, Toronto, Ontario, were taken at a point a few miles distant from the orchard. These are presented in Figure 1. Although the total precipitation for 1930 was normal, the major part occurred during the winter months and, as the chart shows, 1930 was very dry during the growing season. The years 1931 and 1932 were both above normal in total precipitation although they could not be classed as excessively wet. The distribution was reasonably normal thoughout both years.

## TEMPERATURE VARIATIONS

*Daily and Weekly.* Figure 2 is a weekly chart of the temperatures of the air and three depths of soil covering the period July 14 - 20, 1930; Figure 3 is for the period January 11 - 17, 1932. These are representative of the warmest and coldest periods during the time temperatures were recorded.

The range of temperature variation during the weeks mentioned is:—

| July 14 - 20, 1930. | Air | Soil 4″ | 12″ | 24″ |
|---|---|---|---|---|
| Daily variation | 20-40° | 4-12° | 1-5° | 0-2° |
| Weekly variation | 59° | 12° | 6° | 4° |
| Weekly maximum and minimum | 95-36° | 78-66° | 75-69° | 68-64° |
| January 11 - 17, 1932. | Air | Soil 4″ | 12″ | 24″ |
| Daily variation | 8-26° | 3-10° | 2-6° | 0-2° |
| Weekly variation | 34° | 16° | 10° | 6° |
| Weekly maximum and minimum | 55-21° | 44-28° | 42-32° | 37-31° |

It is evident, both in summer and winter, that the daily or weekly variations in temperature are greatest in air and become less for each increase in soil depth. Winter temperatures show less *weekly* variation in air and slightly greater changes in all depths of soil than do the summer records. The *daily* temperature range is much less for air in winter than in summer and about the same for all soil depths both winter and summer. There is no object in giving a more detailed quantative interpretation to these data as they cover only two short, selected periods.

*The time of temperature change* in the daily cycle cannot be definitely established for all periods. The time and degree of the change in air temperature are materially influenced by the time, rapidity and degree of the daily variation, so that it is impossible to fix any narrow, definite time at which maximum and minimum occur. Similarly, response of soil temperature to fluctuations in air is not altogether constant in time or amount, depending on the degree of air temperature change and the time over which it occurs. Summer air temperature usually reaches a maximum between 12.00 and 2.00 P.M., occasionally continuing until 4.00 P.M. The minimum was generally around 4.00 A.M., continuing until 6.00 A.M. There was usually a rapid rise in temperature at 6.00 A.M. with a similar drop at 6.00 P.M. but, in both cases, the movement had slackened by 10.00 A.M. and P.M. respectively.

It is impossible to establish any daily maximum or minimum during the winter, the daily rhythm of rise and fall, which occurs in the summer, being absent. During the summer period mentioned, the sun rose at 4.50 A.M. and set at 7.55 P.M. The early incidence of the temperature fall, and the lateness of the rise, was undoubtedly influenced, to a considerable measure, by the shading effect of the trees. It is probable that, otherwise, the rise and fall in air temperature would closely follow sunrise and sunset, and the maximum and minimum would not be as long continued.

Soil temperatures evinced a much more regular rise and fall than did air temperatures. Winter soil temperatures, although changing slowly in direct relation to air temperature, do not show any definite lag therefrom nor any regular variation in time. This is undoubtedly due in some measure to the relatively small daily variation in air during winter but chiefly to the change in direction of winter air temperature largely irrespective of time. That there is a very considerable lag in the response of soil to air temperature changes is clear and, also, that this time lag increases with depth. The summer soil temperatures show a definite time lag from the air. In 4 inches of soil the maximum temperature occurred at 8.00 to 10.00 P.M. and the minimum at 10.00 to 12.00 A.M., a lag of from 6 to 7 hours from air temperatures. At 12 inches depth, the maximum and minimum occur at 12.00 P.M. and A.M. respectively, a lag of 10 hours. The 24 inch soil depth has similarly a lag of approximately twenty-four hours.

Space prevents the presentation of weekly charts for each month, but it would appear that there might be, for time of temperature change, a gradual gradation from these two extremes, during the intervening months, which cover the spring and fall periods.

TABLE 1.—AVERAGE MONTHLY TEMPERATURE

| Position | 1930 | | | | | | 1931 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | July | Aug. | Sept. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | Apr | May | June |
| Air | 73 | 70 | 66 | 51 | 41 | 27 | 24 | 24 | 33 | 45 | 57 | 65 |
| 4″ Soil | 75 | 72 | 66 | 52 | 42 | 30 | 28 | 29 | 34 | 49 | 59 | 69 |
| 12″ Soil | 74 | 72 | 68 | 55 | 44 | 34 | 30 | 30 | 36 | 46 | 57 | 67 |
| 24″ Soil | 67 | 66 | 62 | 49 | 39 | 31 | 27 | 28 | 29 | 40 | 51 | 62 |

| Position | 1931 | | | | | | 1932 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | July | Aug. | Sept. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. | May | June |
| Air | 73 | 68 | 64 | 53 | 44 | 33 | 32 | 30 | 25 | 39 | 54 | 66 |
| 4″ Soil | 77 | 73 | 68 | 54 | 45 | 35 | — | 32 | 31 | 44 | 58 | 70 |
| 12″ Soil | 75 | 72 | 67 | 56 | 47 | 38 | 37 | 34 | 34 | 42 | 57 | 67 |
| 24″ Soil | 68 | 67 | 63 | 52 | 42 | 35 | 34 | 30 | 30 | 37 | 51 | 61 |

*Monthly and Seasonal Temperatures.* Table 1 gives the average monthly temperatures from July 1930 to July 1932 and Figure 4 is a graph of these data. The figures were arrived at by use of the daily maximum and minimum. Data were computed to the nearest degree since fractions thereof would have little significance in the discussion.

The average monthly air temperature is always lower than that in 4 inches of soil. The difference is relatively small but consistent and only in one month, September 1930, does the average air temperature rise to equal the 4 inch soil depth.

In 12 inches of soil, the avearge monthly temperature is higher than the air temperature except in May 1931 when they were equal. At this depth (12″) the temperature is higher from about September to March, inclusive, and lower from April to August than for a similar period at the 4 inch depth. The actual time at which this change-over occurs may vary from year to year, but in general the soil at 4 inches was warmer in the late spring and summer although colder in the fall, winter and early spring than at 12 inch depth.

The trend shown in the 12 inch soil depth is more evident when the data for the soil at a depth of 24 inches are considered. The air temperature was lower than the soil at 24 inches for December and January, but, except for the winter months, air temperatures were always higher. Again, the actual time of the change must vary with the year. The average monthly temperatures at the 24 inch soil depth were lower than in 4 inches of soil, except for the month of December, and they were always lower than the average temperatures for the 12 inch depth.

The average monthly temperature, for all depths of soil and air, fell below 40° in the months of December to March. The soil at 24 inches was on the border line of this temperature in November and April. The average temperature was above 50° for all positions for the months of May to October inclusive.

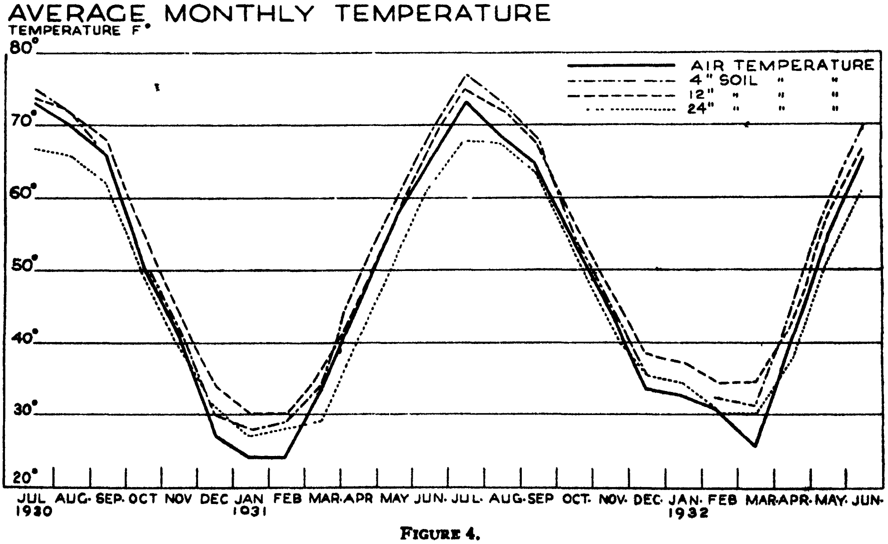

FIGURE 4.

The absolute maximum and minimum temperatures which occurred during the period are of little value as they were often closely approached if not duplicated. The highest temperature recorded was for July 1, 1931, being 105° in air. The maximums were in descending order in all cases: air; soil at 4″; 12″; 24″. The lowest temperatures recorded were in December 1930 and January 1931, being -18°F. in air. The lowest soil temperatures were: 4 inches 20°; 12 inches 25°, and 24 inches 26°. It is evident from the records that no soil approached the air maximum temperature within 10° or came within 20° of the minimum. Usually the latter difference was from 30-35°.

## DISCUSSION

Smith (*1*) gives a very complete account of the daily and seasonal air and soil temperatures at Davis, California and (*2*) a comparison of day and night soil and air temperatures. His work covers a period of February to September 1925 and January to June 1927 for air and soil at ½, 3, 6, 12, 24 and 36 inch depths. Climatic differences make it inadvisable to attempt to compare the two sets of data but some of his findings, even though he worked with a loamy soil underlain at 3 feet by fine sand, are of interest, in connection with the present work. One-half and 36 inch depths are not recorded in our data. The narrowing of the range of temperature variation with increasing depth is similar to that reported here as well as the narrower range of variation in winter in comparison to summer. The lag of soil from air temperature was in general quite similar to that reported by Smith, except that there was, in the data submitted, a considerably longer lag at 4″ depth than he reported for 3″. There is no attempt in this work to correlate "atmospheric" with "soil" climatic data.

McCollock and Hayes (*3*) report studies in Kansas of yearly temperature cycles under greater variations in temperature than occur in Ontario. The lessening of temperature variation with depth of soil is evident, although the lag in temperature response was much longer than the Ontario data. There was, in our work, no sudden overturn of temperatures as was found in Kansas in March and the end of October. There, the greatest depth of soil, which showed the highest temperature, quickly changed to the position of lowest temperature, following the rise in temperature of the readings in shallower soil. This was reversed in late October. There is a distinct but gradual change shown for our data, at about the same time and in a similar direction. The divergence of temperature lines, for air and various soil depths, winter and summer, is shown in Figure 4. McCollock and Hayes show a similar but more marked condition. It is probable that the difference in degree of variation in the position of the temperature at various soil depths during the season, as noted between our data and McCollock's, is due to differing climate and, to a lesser extent, changing seasonal conditions. Our data for the two years does not agree perfectly in detail, one year with another.

It would seem from the work of Buoyoucos (*4*, *5*) that there would be a relatively rapid response to heat and cold changes from the air through the sandy soil under discussion. It was pointed out that the ground cover was at all times relatively light, while although the snowfall was 65″ in 1930-31 and 32″ in 1931-32, this did not remain long in this district. There was never a thick blanket of snow on the ground. These considerations explain the drop in temperature of the 24 inch depth below the 4 and 12 inch depths during the winter. From his findings (*6*) it would seem that there was very little actual freezing of soil at any depth during the winter of 1931-32 and only a moderate amount in the winter of 1930-31.

## ACKNOWLEDGMENTS

Sincere thanks and appreciation are due the Norfolk Orchards Limited, Simcoe, Ontario, for permission to install and operate the instruments in their orchards. Miss L. Heringa, Department of Horticulture, made the charts and her assistance in this work is gratefully acknowledged.

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# FURTHER STUDIES OF THE INHERITANCE OF SPORE COLOUR AND PATHOGENICITY IN CROSSES BETWEEN PHYSIOLOGIC FORMS OF *PUCCINIA GRAMINIS TRITICI*[1]

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[Received for publication December 1, 1933]

## Introduction

The work reported in the present paper represents a continuation of previously reported investigations (*3*, *4*, *5*) on the inheritance of pathogenicity and urediospore colour in *Puccinia graminis tritici* Erikss. and Henn. The aim of these investigations is to work out as far as possible the inheritance of those characters of physiologic forms that can be made the subject of inheritance studies. As physiologic forms are so similar morphologically as to be practically indistinguishable, the investigation must be confined to characters that are essentially physiological. The most important character which can be studied is the pathogenicity of the physiologic forms as judged by the infection types produced on the differential hosts used in their identification. The only other character which can as yet be conveniently made the basis of inheritance studies is urediospore colour. The normal stem rust urediospore contains two pigments, an orange pigment in the cytoplasm and a more deeply coloured pigment in the spore-wall. The red colour of the spore is the combined effect of these pigments. An opportunity for the study of the inheritance of spore colour was furnished by the appearance of two aberrantly-coloured physiologic forms (*2*), an orange form in which the spore-wall pigment was lacking and two greyish-brown forms in which the cytoplasmic pigment was lacking. Crosses between these strains have formed a basis for a study of the inheritance of both urediospore colour and pathogenicity.

The inheritance studies hitherto reported have been confined mainly to a single cross between form 9*a* (orange)[3] and form 36 (greyish-brown). Obviously generalizations as to the inheritance of pathogenicity in *P. graminis tritici* can not be safely made on the basis of inheritance studies of a single cross. It was, therefore, thought necessary to carry on similar progeny studies on several other crosses to determine the general behaviour of hybrid forms, particularly in the $F_2$ and $F_3$ generation. The present paper presents the results of several such progeny studies.

As a number of crosses were investigated, it was impossible on account of the large amount of work involved to study a sufficiently large population of each cross to enable the inheritance of pathogenicity and spore colour to be placed on a factorial basis. A detailed genetic study with this purpose in view should undoubtedly be one of the main objectives of these investigations; but this objective can only be attained by the study of large populations derived from crosses between homozygous parental forms. As crosses between homozygous forms have been made recently, it may be possible to carry out such a study in the near future.

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[1] Contribution No. 395 from the Division of Botany, Experimental Farms Branch, Department of Agriculture, Ottawa, Canada.

[2] Plant Pathologist, Senior Plant Pathologist, and Assistant Plant Pathologist respectively.

[3] Form 9*a* differs from form 9 only by its infection type on the varieties Marquis and Kota which is (3–) instead of (4).

As the work reported in the present paper is a continuation of that previously reported, it seems advisable to give a brief account of the more important results of the earlier studies. The previous work on the inheritance of pathogenicity may be briefly summarized as follows: 1. It has been established that physiologic forms of *P. graminis tritici* can cross readily with one another. 2. In the majority of the crosses the first generation hybrid forms differ pathogenically from both of the parental forms. In some crosses, however, the hybrid forms are pathogenically identical with one or the other of the parental forms, in which cases the dominance of one parental form over the other is complete. 3. Selfing of the $F_1$ hybrid forms leads to the production of an $F_2$ hybrid generation consisting of several physiologic forms among which the two original parental forms commonly occur. 4. Most physiologic forms collected in nature are heterozygous for pathogenicity.

The previous studies on the inheritance of urediospore colour led to the following conclusions: 1. Crosses between orange forms and greyish-brown forms result in an $F_1$ hybrid form of normal (red) spore colour. 2. A selfing of the normally-coloured $F_1$ hybrids leads to an $F_2$ generation composed of strains of four distinct urediospore colours, red, orange, greyish-brown, and white.

## METHODS

The methods used in the crossing and selfing of physiologic forms have been described previously in detail (*3*, *4*). As the present paper is chiefly concerned with the selfing of $F_1$ and $F_2$ hybrid forms, it will be sufficient to outline briefly the methods employed in the selfing studies.

Teliospores of each form selected for selfing were developed on adult plants of susceptible varieties. These plants were infected with a pure culture of the physiologic form to be tested and were kept in a greenhouse maintained at rather low temperatures (55°—65°F.) until telial development was completed. While the rust on these plants was still in the uredial stage each form was again checked to ascertain its purity. When telial formation was completed the teliospores were frozen and subsequently brought to germination by a method previously described by Johnson (*1*).

When the teliospores had begun to germinate, several barberry plants were infected by each form whose progeny was to be studied. After the development of the haploid pustules their nectar was intermixed to ensure an abundant production of aecia. The aecial cups were picked off singly at random, each cup being broken open in a drop of water on a glass slide. The contents of each aecium were used to inoculate a single seedling leaf of the susceptible variety, Little Club. The cultures of mono-aecial origin thus established were identified by their infection types on the differential varieties used for the determination of physiologic forms.

It was not possible to carry out selfing studies on all of the $F_1$ hybrid forms which had been obtained from the crosses between various physiologic forms. Selfing studies, however, were made on most of the hybrid forms which promised to yield interesting information on the inheritance of pathogenicity or colour, or both. Still less was it possible to make selfing studies on all of the numerous physiologic forms comprising the $F_2$ generation of these crosses. Consequently, a few $F_2$ cultures from each cross were selected for selfing in order that some information might be obtained as to the character of the forms in the $F_3$ generation.

## The Inheritance of Pathogenicity

### CROSSES BETWEEN FORM *9a* AND FORM 36

Several crosses have been made between form *9a* (orange) and form 36 (greyish-brown). These forms were thought particularly suitable for crossing studies on account of striking differences in the colour of their urediospores and in their pathogenicity (Table 1). Previous work (*5*) had shown that form *9a* (orange) was homozygous for both colour and pathogenicity while form 36 (greyish-brown) was homozygous for colour but heterozygous for pathogenicity. Consequently, progeny studies of the different hybrid forms should, in theory, yield similar results for the inheritance of colour but need not be expected to yield identical results for the inheritance of pathogenicity. In this paper the results on the inheritance of colour and of pathogenicity will be discussed separately.

With one exception, the hybrids between these two forms were identified as form 17 or form *17a*, that is, in the crosses *9a* × 36[4] the hybrid rust was identified as form *17a*, while in the reciprocal crosses 36 × *9a*, the hybrid rust was identified as form 17. The rather slight differences between the hybrids originating from opposite sides of the crosses have been attributed (*5*) to the influence of the cytoplasm of the maternal parent form.

### Cross I (a)—*9a* (orange) × 36 (greyish-brown)

The selfing of the $F_1$ form (*17a*) has been reported in a previous paper (*5*); but, in order to present a complete picture of the progeny studies of this cross, the distribution of physiologic forms in the $F_2$ generation is again presented in Figure 1.

The inheritance studies of this cross were continued by selfing certain selected $F_2$ cultures. The distribution of physiologic forms in the $F_3$ generation is also recorded in Figure 1. An examination of Figure 1 will show that the physiologic forms in the $F_3$ generation are, with two exceptions, the same ones which were present in the $F_2$ generation. Of the seven $F_2$ cultures selected for selfing, one (culture No. 63) is homozygous for pathogenicity while the remaining cultures are, with the possible exception of No. 40, in a heterozygous condition.

Attention might here be called to the differences in breeding behaviour of different cultures of the same physiologic form. The two $F_2$ cultures of form 1 which were selfed were strikingly different in breeding behaviour as judged by their $F_3$ progeny. Culture No. 1 produced 16 cultures of form 1 and two cultures of form 36, while culture No. 92 produced two cultures of form 1, two of form 36 and twelve of form 57. Similar discrepancies were found in the breeding behaviour of the three cultures of form *1a* which were selfed. It is clear, therefore, as has indeed been pointed out in a previous paper (*3*), that different cultures of the same physiologic form may be genotypically different.

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[4] In crosses recorded in this manner the pycniospore-containing nectar was transferred from pustules of the last-mentioned to pustules of the first-mentioned form, the aecia from which the hybrid arose being developed in pustules of the first-mentioned form.

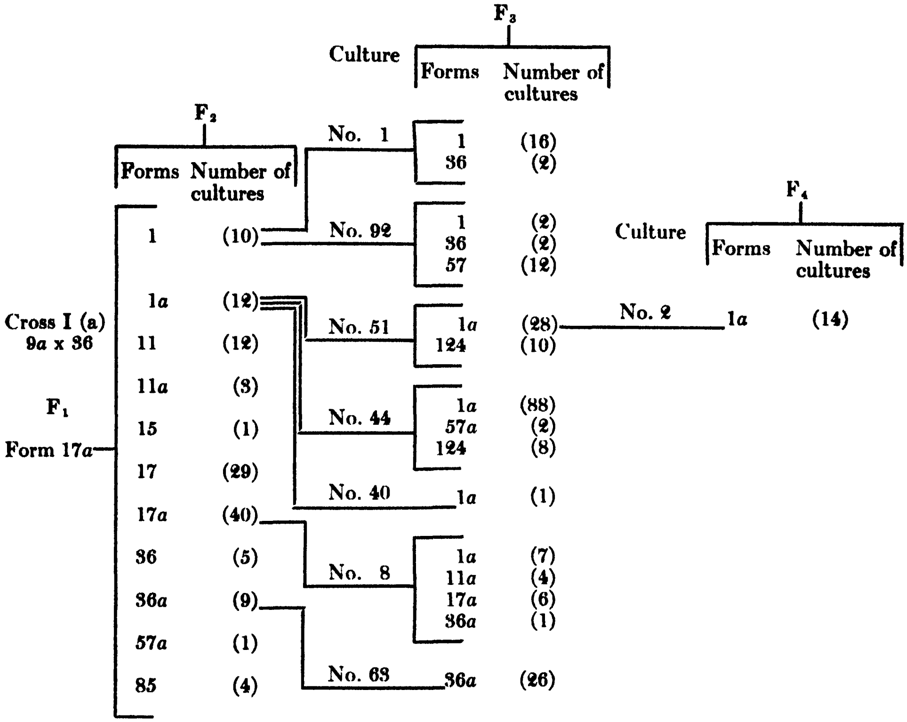

Figure 1. $F_2$, $F_3$, and $F_4$ progeny of cross I(a) — form 9*a* x form 36.

Explanatory Note: The figures in parenthesis represent the number of cultures of each physiologic form identified. The numbers superimposed on the lines connecting the different generations ($F_2$, $F_3$ and $F_4$) are merely the accession numbers assigned to the cultures studied. In all physiologic forms followed by the letter *a* the infection type on the varieties Marquis and Kota is (3) -- instead of (4) which is the characteristic infection type of those forms, but these differences were not thought sufficient to warrant the creation of new forms.

The inheritance of pathogenicity in this cross is apparently not very complex. The fact that only eight physiologic forms have appeared in the combined $F_2$ and $F_3$ populations would suggest that the inheritance of pathogenicity in this cross is possibly governed by a two-factor difference between the two parental forms.

Only one of the $F_3$ lines has been selfed (Figure 1). The $F_4$ progeny of this line indicates that it is homozygous for pathogenicity.

Cross I (b)—9*a* (orange) × 36 (greyish-brown) and reciprocal cross

The $F_1$ hybrid from the cross 9*a* × 36 was identified as form 17*a* and that from the reciprocal cross 36 × 9*a* was identified as form 17. Both $F_1$ hybrid forms were selfed. The results of these selfing studies are incorporated in Figure 2.

A comparison of the $F_2$ progeny of this cross with that of cross I (a) (Figure 1) will show that, in the cross now under discussion, a number of physiologic forms appeared which were not present in the $F_2$ progeny of cross I (a). The presence of the new forms is due to transgressive segregation which was not evident in the study of the earlier cross. This transgressive segregation is detected by the infection types on the varieties Marquis and

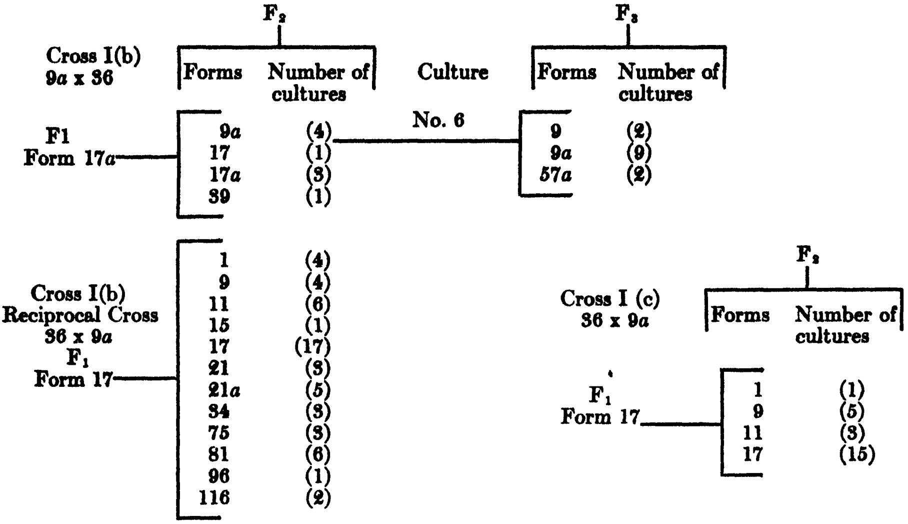

Figure 2. $F_2$ and $F_3$ progeny of cross I(b) — form 9*a* x form 36 and its reciprocal cross, and of cross I(c) — form 36 x form 9*a*.

Einkorn. For example, both of the parental forms produce a (3) type of infection on Einkorn, but in the $F_2$ progeny of the present cross a (1) type of infection is produced on Einkorn by five forms—21, 34, 75, 81 and 116. The difference in the composition of the $F_2$ progenies of the two crosses is probably attributable to the heterozygosity of one of the parental forms, namely form 36.

Only one of the $F_2$ cultures from Cross I (b) was selfed. This culture, form 9*a* proved heterozygous for pathogenicity (Figure 2).

### Cross I (c)—36 (greyish-brown) × 9*a* (orange)

The $F_1$ hybrid of this cross was identified as form 17. The small $F_2$ population which was studied (Figure 2) comprises four physiologic forms all of which had, however, appeared in the $F_2$ population of cross I (b). Form 17 forms a large proportion of the $F_2$ progeny as it does in other crosses between form 9 and form 36.

## CROSSES BETWEEN FORM 52 AND FORM 9*a*

Form 52 differs from form 36 chiefly by the infection type produced on the variety Vernal on which it produces a (4) type of infection while form 36 produces a (1) type. Consequently the elements entering into these crosses are probably not very different from those playing a part in the crosses between forms 9*a* and 36.

### Cross III (a)—52 (greyish-brown) × 9*a* (orange)

In this cross form 9 proved dominant over form 52, and the $F_1$ hybrid was identified as form 9 (red). The form was selfed and a small $F_2$ population studied. Three forms, 9, 15, and 117 appeared in the $F_2$ generation. Three of the $F_2$ cultures were selected for further selfing studies to determine the nature of their $F_3$ progeny. All three proved heterozygous (Figure 3). The data presented in Figure 3 indicates that inheritance of pathogenicity in this

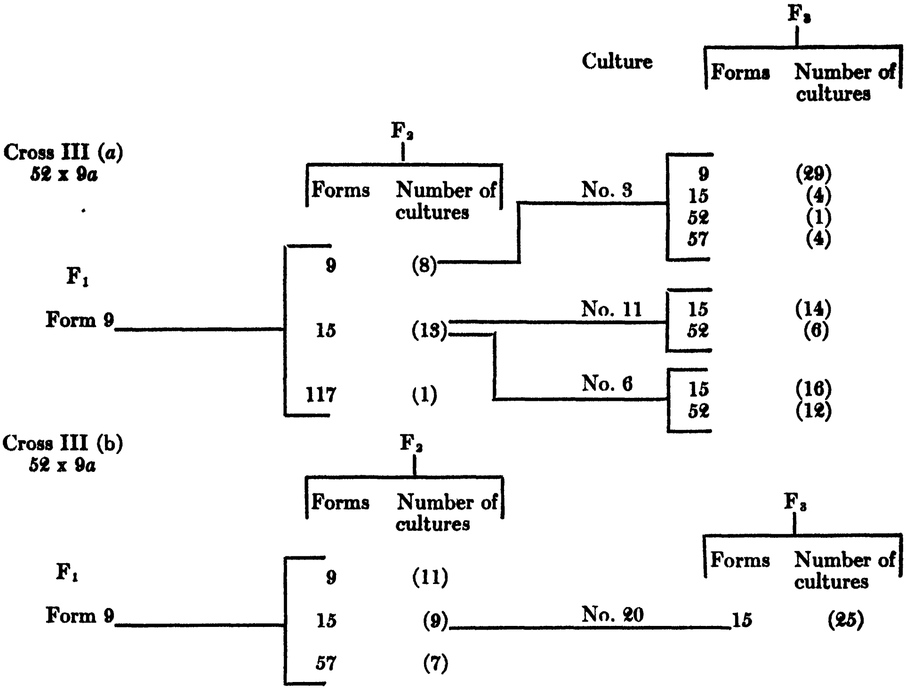

Figure 3. $F_2$ and $F_3$ progeny of cross III(a) — form 52 x form 9*a*, and of cross III(b) — form 52 x form 9*a*.

cross is rather simple. Only five physiologic forms appeared in the combined populations of the $F_2$ and $F_3$ generations. The fact that the selfing of the two cultures of form 15 produced in each case a population consisting of only two forms suggests that each of these cultures is heterozygous for a single factor.

Cross III (b)—52 (greyish-brown) × 9*a* (orange)

As in cross III (a), the $F_1$ hybrid was identified as form 9. Selfing of the $F_1$ hybrid led to an $F_2$ population consisting of three forms, 9, 15, and 57 (Figure 3). Only one of the $F_2$ cultures was selfed. This culture, form 15, proved homozygous for pathogenicity as shown by the fact that the twenty-five $F_3$ cultures studied were all determined as form 15. Two genetically distinct types of form 15 have, therefore, been obtained from the crosses between forms 9*a* and 52, the heterozygous cultures of cross III (a) and the homozygous one of cross III (b).

### A CROSS BETWEEN FORM 14 AND FORM 36

Cross IV (b)—36 (greyish-brown) × 14 (red) and reciprocal cross

The $F_1$ hybrid of the cross 36 × 14 was identified as form 88 and that of the reciprocal cross 14 × 36 as form 14. The difference between the hybrid forms arising from opposite sides of the cross has been attributed (*5*) to the influence of the cytoplasm of the parental forms on the inheritance of pathogenicity. The cytoplasmic influence, in this cross, was detected only by the infection types produced by the hybrid forms on the variety Marquis on which the hybrid form arising from the form-14 side of the cross produced a

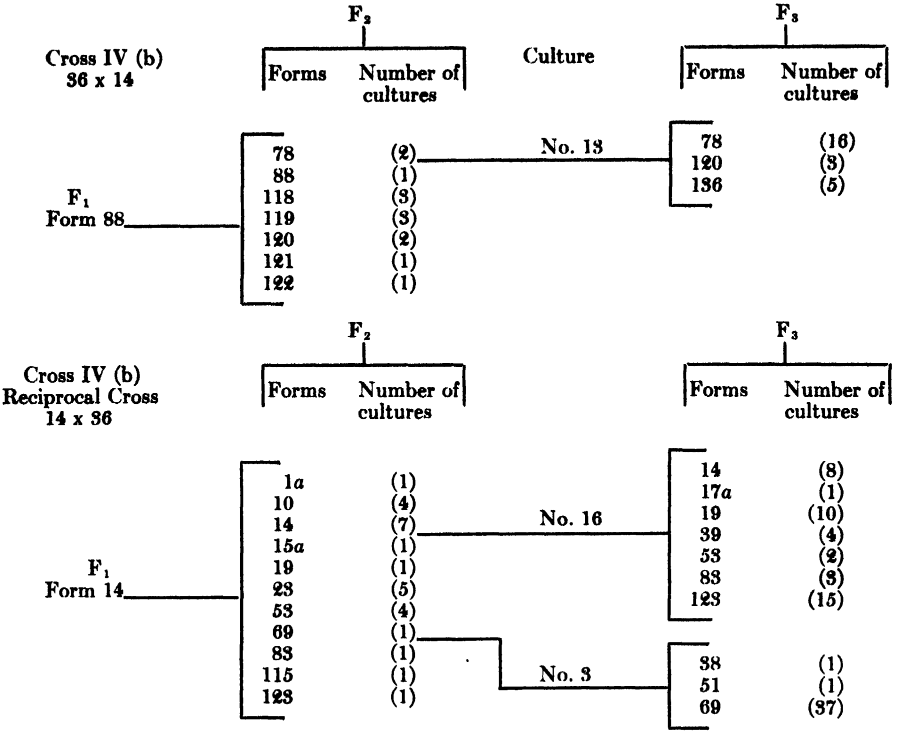

Figure 4. $F_2$ and $F_3$ progeny of cross IV(b) — form 36 x form 14, and of its reciprocal cross — form 14 x form 36.

(1) type of infection as did the form-14 parent while the hybrid form arising from the form-36 side of the cross produced an (x) type, a result attributed to the influence of the form 36 cytoplasm. Apart from this cytoplasmic influence form 14 was, in this cross, dominant over form 36, as judged by the infection types of the hybrid forms on the other differential varieties.

The hybrid forms arising from the two sides of the cross were selfed chiefly with the object of determining how far this cytoplasmic influence persisted in the progenies. The results of these selfing studies are given in Figure 4. It is clear from an examination of Figure 4 that the same physiologic forms did not occur in the $F_2$ generations of the two hybrid forms. The difference in the $F_2$ progeny of the reciprocal hybrids is due largely to the fact that the infection types attributed to cytoplasmic inheritance did persist in the $F_2$ generation. The majority of the physiologic forms arising from the selfing of form 88 produce an (x) type of infection on Marquis while two forms, 121 and 122, produce a (4) and a (3) + type respectively. The fact that on Marquis the infection types of all the $F_2$ cultures are not identical is perhaps evidence of segregation of pathogenic factors whose expression is partially inhibited by the cytoplasm. Selfing studies on one of the $F_2$ cultures, form 78, showed that the (x) type of infection still persists in the $F_3$ generation. The forms arising from the selfing of the other $F_1$ hybrid, form 14, show the persistance in the $F_2$ generation of the (1) type of infection on Marquis, which is characteristic of the form-14 parent. Only two cultures (one culture of form 1*a* and one culture of form 15*a*) showed a slight deviation from the (1) type of infection. A selfing of two of the $F_2$ cultures, forms 14 and 69, showed a similar persistence of the (1) type of infection in the $F_3$ generation on Marquis.

In view of the large number of physiologic forms recovered in the rather small $F_2$ and $F_3$ populations studied, it is probable that the inheritance of pathogenicity in this cross is conditioned by several factors. The number of physiologic forms in the progenies from both sides of the cross is increased by the occurrence of transgressive segregation which is detected by the reactions of the variety Vernal. This variety is resistant to both the parental forms but is susceptible to several of the $F_2$ and $F_3$ cultures.

TABLE 1 —MEAN INFECTIONS PRODUCED BY PARENT AND HYBRID PHYSIOLOGIC FORMS OF *PUCCINIA GRAMINIS TRITICI* ON TRITICUM DIFFERENTIAL VARIETIES

| Physiologic Forms | Reaction of differential varieties* | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | L.C. | Ma. | Krd. | Ko. | Arn. | Mnd. | SpM. | Kub. | Aç. | Enk. | Ver. | Kpl. |
| 1 | 4 | 4- | 0 | 3+ | 1= | 1 | 1= | 3+ | 3++ | 3 | 0; | 1= |
| 9 | 4 | 4- | 0 | 3++ | 4 | 4= | 4= | 4= | 3++ | 3+ | 4= | 1- |
| 10 | 4+ | 2- | 3++ | 2 | 4 | 4 | 4 | 3++ | 4 | 3+ | 1= | 1= |
| 11 | 4- | 4= | 3++ | 3+ | 4= | 4= | 4= | 3++ | 3++ | 3 | 1= | 1= |
| 14 | 4+ | 2- | 0; | 1++ | 3++ | 3++ | 3++ | 3++ | 3++ | 3 | 1= | 0; |
| 15 | 4++ | 4- | 4= | 3++ | 4= | 4= | 4= | 3++ | 3++ | 3+ | 4= | 1= |
| 17 | 4 | 4 - | 0 | 3+ | 4= | 4= | 4= | 3++ | 3++ | 3 | 1= | 1= |
| 19 | 4 | 2- | 0; | 3- | 4= | 4= | 4= | 3++ | 3++ | 3 | 0; | 1= |
| 21 | 4 | 4 | 0 | 3++ | 4- | 4- | 4- | 4= | 3++ | 1= | 0; | 1= |
| 23 | 4 | 2 | 1- | 1= | 1 | 1= | 1- | 3+ | 3++ | 3 | 0; | 0; |
| 34 | 4+ | 4- | 4 | 4= | 4 | 4= | 4= | 4= | 3++ | 1= | 0; | 1= |
| 36 | 4 | 4 | 4- | 3++ | 1= | 1= | 0; | X | 3++ | 3 | 0; | 1- |
| 38 | 4 | 2= | 4- | 3 | X+ | X± | X+ | X+ | X++ | 4- | 1= | 1+ |
| 39 | 4- | 2= | 4= | 3+ | 4+ | 3++ | 4 | 4= | 3++ | 4= | 1= | 1- |
| 51 | 4 | 2 | 3= | 0; | 0; | 0; | 0; | 4 | 3+ | 4- | 4- | |
| 52 | 4 | 4 | 4 | 4 | 1= | 1= | 1= | X | 4 | 4 - | 4+ | 1- |
| 53 | 4 | 2± | 0 | 1 | 4 | 4 | 4 | 4 | 4 | 3± | 3± | 1 |
| 57 | 4 | 4- | 0 | 4- | 1 | 1 | 1 | 3+ | 4- | 3+ | 3+ | 1 |
| 69 | 4 | 2+- | 0 | 0; | 1± | 1+ | 1± | 3+ | 3± | 3 | 3+ | 1 |
| 75 | 4 | 3+ | 2+ | 0; | 3+ | 3+ | 3+ | 4- | 3+ | 1 | 0; | 1 |
| 78 | 4 | X | 0 | 3= | 3-c | 3-c | 3-c | 3+ | 3+ | 3+ | 1 | 1 |
| 81 | 4 | X | 0 | 1+ | 4 | 4 | 4 | 4 | 4- | 1- | 1-- | 1 - |
| 83 | 4 | 1+ | 3 | 1 | 3+ | 3+ | 3+ | 3+ | 3+ | 3+ | 3+ | 1 |
| 85 | 4 | 4- | 0 | 3± | 4- | 4 | 4 | 4 | 4 | 3+ | X | 1 |
| 88 | 4 | X | 0 | 1± | 4 | 4 | 4 | 4 | 4 | 3+ | 1 | 1 |
| 96 | 4 | X | 4 | X | 4 | 4 | 4 | 4 | 3+ | 3+ | 1 | 1 |
| 115 | 4 | 2- | 3= | 3= | 4 | 4- | 4 | 4 | 4- | 3+ | 3± | 1- |
| 116 | 4 | 4- | 0 | 3 | 4 | 4 | 4 | 4 | 4- | 1 | 4 - | 1- |
| 117 | 4 | 4- | 0 | 0; | 4- | 4- | 4- | 4- | 4 | 3+ | 3+ | 1- |
| 118 | 4 | X | 0 | 1- | 1 | 1- | 1- | 4 | 4 | 3+ | 1- | 1- |
| 119 | 4 | X | 0 | 0; | 4 | 4 | 4 | 4 | 4 - | 3+ | 3+ | 1 - |
| 120 | 4 | X | 0 | 3= | 4 | 4 | 4 | 4 | 4- | 3+ | 3 | 1- |
| 121 | 4 | 4- | 0 | 0; | 1 - | 1- | 1- | 4 | 3+ | 3 | 3+ | 1 |
| 122 | 4- | 3+ | 4- | 0; | 4 | 4 | 4 | 4 | 4- | 3+ | 1- | 1 |
| 123 | 4 | 2- | 0 | 3- | 3+ | 4- | 4 | 4 | 4- | 3+ | 3+ | 1 |
| 124 | 4 | 3-c | 0 | 3=c | 0; | 0; | 1= | 3+ | X | 3 | X- | 1 |
| 136† | 4 | X | 0 | 3= | 0; | 0; | 0; | 4- | 4 | 4- | 1- | 1 |

Explanation of symbols: O—immunity, 1—high resistance, 2—moderate resistance, 3—moderate susceptibility, 4—complete susceptibility, X—indeterminate (mesothetic) reaction, (;)—hypersensitive flecks. Plus and minus signs indicate a slightly greater and smaller amount of rust than the infection types to which they are suffixed.

* Explanation of abbreviation of varietal names; L.C. = Little Club, Ma. = Marquis, Krd. = Kanred, Ko. = Kota, Arn. = Arnautka, Mnd. = Mindum, SpM. = Speltz Marz, Kub. = Kubanka, Ac. = Acme, Enk. = Einkron, Ver. = Vernal, Kpl. = Khapli.

† The authors are indebted to Dr. E. C. Stakman, and Dr. M. N. Levine for assigning a number to this physiologic form.

## THE INHERITANCE OF UREDIOSPORE COLOUR

In a previous paper (*5*) an account was given of a number of crosses between physiologic forms of orange and of greyish-brown urediospore colour. The $F_1$ hybrids of these crosses possessed, in most cases, urediospores of normal (red) colour. Some exceptions, however, occurred in which the hybrid spores were orange in colour. By a selfing study of one of the red hybrid forms it was shown that $F_2$ cultures of four distinct spore colours were produced, namely: red, greyish-brown, orange, and white.

Selfing studies have now been carried out on several $F_1$ hybrids as well as on some of the $F_2$ cultures with the purpose of throwing further light on the inheritance of urediospore colour. The observations on the inheritance of spore colour have been carried out, for the most part, simultaneously with the pathogenicity studies already reported in the present paper. The $F_2$ and $F_3$ populations studied have in all cases been too small to permit the inheritance of spore colour to be placed on a statistically proved basis Nevertheless, enough information has been obtained to indicate in a general way the manner of colour inheritance.

### CROSSES BETWEEN PHYSIOLOGIC FORMS OF NORMAL (RED) UREDIOSPORE COLOUR

Several crosses have been made between physiologic forms of red uredial colour. Crosses between form 9 and forms 15 and 53 produced $F_1$ hybrids of red uredial colour. A cross between form 17 and form 49, which has been previously reported, proved an exception through the appearance of a greyish-brown hybrid form in its $F_1$ progeny.

Selfing studies on the red $F_1$ hybrids of the above-mentioned crosses showed that with one exception they were homozygous for red urediospore colour. The exception was the $F_1$ hybrid of the cross between form 9 and form 15 in whose $F_2$ progeny both red and greyish-brown physiologic forms appeared. This result has previously (*5*) been attributed to the heterozygous condition of the form-15 parent. Although the majority of physiologic forms occurring in nature are undoubtedly homozygous for colour, it has been shown (4) that certain naturally-occurring forms are heterozygous for the factor determining greyish-brown urediospore colour. Of the naturally-occurring physiologic forms which thus far have been selfed none has given rise to orange uredia in its progeny.

### CROSSES BETWEEN ORANGE AND GREYISH-BROWN PHYSIOLOGIC FORMS

All the crosses between orange and greyish-brown physiologic forms have produced $F_1$ hybrids of red urediospore colour. In some of the crosses, however, orange as well as red $F_1$ urediospores were formed. Selfing studies have been made on the $F_1$ hybrid forms of both these colour types with results which are presented in Table 2.

With the exception of cross I (a) which has been previously reported (*5*), the $F_2$ populations studied were so small that there is no assurance that the data for the distribution of colour are truly representative of colour inheritance. Of the five red $F_1$ hybrid cultures which were selfed (Table 2) two produced $F_2$ progeny consisting of red, greyish-brown, orange, and white cultures; one produced red, greyish-brown, and orange but no white cultures;

one produced red and greyish-brown cultures only; and one produced an all-red progeny.

The $F_1$ culture described as Mars Yellow (a colour almost intermediate between red and orange) produced an $F_2$ progeny divisible into four colour groups; Mars Yellow, Sayal Brown, orange, and white. The two first-mentioned groups were lighter in colour than the corresponding red and greyish-brown groups of the other hybrid forms. These colour differences appear to be due to a lighter pigmentation of the spore wall which is evidently an inherited characteristic.

TABLE 2.—DISTRIBUTION OF COLOUR IN $F_2$ GENERATION

| Urediospore colour of parent forms | Urediospore colour of $F_1$ culture | Urediospore colour in $F_2$ | | | |
|---|---|---|---|---|---|
| | | Red | Greyish-brown | Orange | White |
| Cross I (a), 9*a* orange x 36 greyish-brown | Red | 59 | 22 | 47 | 7 |
| " I (b), 36 greyish-brown x 9*a* orange | Red | 48 | 3 | 4 | – |
| " I (b), 9*a* orange x 36 greyish-brown | Red | 7 | 2 | – | – |
| Cross I (c), 36 greyish-brown x 9*a* orange | Mars Yellow | 3* | 2† | 13 | 6 |
| Cross III (a), 9*a* orange x 52 greyish-brown | Red | 11 | – | – | – |
| " III (a), 52 greyish-brown x 9*a* orange | Red | 5 | 2 | 11 | 4 |
| " III (b), 52 greyish-brown x 9*a* orange | Orange | – | – | 20 | 7 |
| Cross IV (b), 36 greyish-brown x 14 red | Red | 9 | 4 | – | – |
| " IV (b), 14 red x 36 greyish-brown | Red | 19 | 8 | – | – |

* The three cultures in the red group had a pronounced yellowish tint and were classified as "Mars Yellow" according to Ridgway's Colour Standards.

† The two cultures in the greyish-brown group were decidedly paler than other greyish-brown cultures and were classified as "Sayal Brown" according to Ridgway's Colour Standards.

The selfing of the orange $F_1$ culture of cross III (b) produced 20 orange and 7 white $F_2$ cultures. This result, therefore, shows heterozygosity for orange colour and indicates that one of the parental forms (52 greyish-brown) was heterozygous for the factor governing the pigmentation of the spore wall.

In order to determine the distribution of colour in the $F_3$ generation, a few $F_2$ cultures of each colour group were selected for selfing. The data obtained from these selfing studies have been incorporated in Table 3. The two red $F_2$ cultures of cross I (a) proved heterozygous, as is shown by the appearance of red and orange cultures in the $F_3$ populations. The red $F_2$ culture of cross I (b) is apparently homozygous for red spore colour. The $F_2$ culture of cross I (a) described as antique brown (somewhat intermediate between red and orange) was almost identical in its breeding behaviour with the before-mentioned Mars Yellow $F_1$ culture of cross I (c). Two cultures of typical red colour, however, appeared in the $F_3$ progeny along with four cultures of the characteristic antique brown colour. At present no satisfactory explanation can be given for the appearance of red cultures in the $F_3$ progeny.

Of the three orange $F_2$ cultures which were selfed, two were found homozygous for colour while one was heterozygous. The heterozygous culture, cross III (a), produced an $F_3$ progeny of 21 orange and 7 white cultures.

TABLE 3.—DISTRIBUTION OF COLOUR IN $F_3$ GENERATION

| Urediospore colour of parent forms | $F_2$ culture number | Urediospore colour of $F_2$ culture | Urediospore colour in $F_3$ | | | |
|---|---|---|---|---|---|---|
| | | | Red | Greyish-brown | Orange | White |
| Cross I(a), 9*a* orange x 36 greyish-brown | 1 | Red | 17 | – | 1 | – |
| | 51 | Red | 34 | – | 4 | – |
| | 92 | Antique brown | 6* | 5† | 4 | 1 |
| | 44 | Orange | – | – | 98 | – |
| | 8 | Orange | – | – | 18 | – |
| | 63 | Greyish-brown | – | 26 | – | – |
| Cross I(b), 9*a* orange x 36 greyish-brown | 6 | Red | 13 | – | – | – |
| Cross III(a), 52 greyish-brown x 9*a* orange | 6 | Orange | – | – | 21 | 7 |
| | 11 | Greyish-brown | – | 12 | – | 8 |
| | 3 | White | – | – | – | 38 |
| Cross III(b), 52 greyish-brown x 9*a* orange | 20 | White | – | – | – | 25 |
| Cross IV(b), 36 greyish-brown x 14 red | 24 | Red | 22 | 2 | - | – |
| Cross IV(b), red x 36 greyish-brown | 16 | Red | 25 | 18 | – | – |
| Cross IV(b), red x 36 greyish-brown | 3 | Red | 39 | – | – | – |

* Four of the cultures in the red group were classified as "antique brown" according to Ridgway's Colour Standards.

† The cultures in the greyish-brown group were classified as "Sayal Brown" according to Ridgway's Colour Standards

Of the two greyish-brown cultures which were selfed one was homozygous for greyish-brown colour, the other was heterozygous and produced an $F_3$ progeny of 12 greyish-brown and 8 white cultures.

The two white $F_2$ cultures were homozygous for white spore colour.

### CROSSES BETWEEN RED AND GREYISH-BROWN PHYSIOLOGIC FORMS

Table 2 contains the colour distribution resulting from the selfing of the red $F_1$ hybrid forms of cross IV (b) between form 14 (red) and form 36 (greyish-brown). Two colour groups only, red and greyish-brown, appeared in the $F_2$ generation. As both parental forms were known to be homozygous for colour these two colour groups were expected to appear in the proportion of three red to one greyish-brown. The fact that the observed data do not fit this ratio exactly is perhaps due to the smallness of the $F_2$ populations.

This study was extended to the $F_3$ generation by a selfing of three of the red $F_2$ cultures. As shown by the data in Table 3 two of the cultures were heterozygous for colour while one was homozygous for red spore colour.

### CROSSES BETWEEN A RED AND A WHITE PHYSIOLOGIC FORM

Two crosses have been made between form 95 of red and form 1*a* of white urediospore colour. In both crosses pycniospore-containing nectar of form 95 was transferred to haploid pustules of form 1*a* (white). In the first cross aecia developed in one of the pustules to which nectar was transferred. The $F_1$ uredial cultures resulting from the inoculation of wheat seedlings with the aecia were identified as form 95*a* (red). In the second cross aecia likewise developed in one of the nectar-receiving pustules of form 1*a* (white) and these aecia gave rise to red uredial cultures which were identified as form 21*a*. As the aecia were in both instances formed in pustules of o·m 1*a* (white) there can be no doubt as to the authenticity of the crosses. These crossing experiments may, therefore, be regarded as an experimental confirmation of the dominance of red spore colour over white.

## DISCUSSION

It is apparent from the results presented in the present paper that the inheritance of pathogenicity is not by any means a simple phenomenon, and, as yet, there is but little evidence to indicate its exact nature. The inconclusiveness of the results is due partly to the fact that homozygous forms were not available as parental material when the earlier crosses were made and partly to the smallness of most of the $F_2$ and $F_3$ populations which have been studied. Certain results which have been obtained point, however, to a Mendelien manner of inheritance. Thus, in some crosses one physiologic form shows dominance over another. Furthermore, when hybrid forms are selfed, the parental forms are not uncommonly recovered in the $F_2$ progeny along with other forms which show some of the pathogenic qualities of the parent forms. Hence there is evidently a segregation and subsequent recombination of factors determining pathogenicity. Segregation undoubtedly occurs during one or the other of the two divisions of the teliospore nucleus, and recombination takes place in the aecial primordia in the leaf tissues of the barberry.

In some of the crosses (e.g., crosses I (a) and III (b)) it has been shown that some of the $F_2$ cultures are homozygous for pathogenicity although the majority are heterozygous, as would be expected if Mendelian laws of inheritance were operative. There is also some evidence that a continued selfing of the progeny of a cross tends towards homozygosity in the forms of later generations. Thus the selfing of $F_2$ cultures generally results in fewer physiologic forms than the selfing of $F_1$ hybrid forms.

Inheritance of pathogenicity is not, however, wholly determined by Mendelian factors as has been pointed out in previous papers (*3*, *5*) in which certain pathogenic characteristics noticeable in the $F_1$ cultures of some crosses were attributed to the influence of the cytoplasm of one or the other of the parental forms. In these crosses, which were made reciprocally, the $F_1$ hybrid forms arising from opposite sides of each cross were not identical in pathogenicity as they should have been if Mendelian factors alone governed the inheritance of pathogenicity. The fact that the differences observed in the reciprocally produced $F_1$ hybrid forms did persist unchanged in their $F_2$ and $F_3$ progeny confirms the original assumption of an extra-nuclear cause. (See text discussion of cross IV (b) ).

The results on the inheritance of urediospore colour are somewhat more definite than those on the inheritance of pathogenicity. Urediospore colour is apparently inherited independently of pathogenicity and not in any way linked with it as was tentatively suggested in an earlier paper (*5*). Normally-coloured urediospores of stem rust possess two pigments, an orange pigment in the cytoplasm and a brownish pigment in the spore-wall. The combined effect of the two pigments is the normal, red colour of stem rust spores. In most strains of stem rust no segregation of colour factors takes place, and urediospore colour is inherited as a unit. The occasional appearance of orange and greyish-brown colour variants has, however, furnished an opportunity of throwing some light on the genetics of colour in stem rust. The following facts have been established through crossing studies with orange and greyish-brown strains. 1. Crosses between orange and greyish-brown strains produce $F_1$ hybrids of normal (red) colour. 2. Selfing of the red $F_1$ hybrids results in an $F_2$ generation composed of red, orange, greyish-brown, and white strains; the red strains are the most numerous, the white strains the least. Selfing studies with the red $F_2$ cultures indicate that they fall into several genetically distinct types. Some are homozygous for red colour; others break up into red, orange, greyish-brown, and white cultures; and still others break up into red and orange cultures. Greyish-brown cultures are either homozygous or heterozygous, the latter breaking up into greyish-brown and white cultures on selfing. Similarly, orange cultures are either homozygous or heterozygous, if the latter they break up into orange and white cultures. The white cultures are all homozygous for white spore colour.

The results of the selfing studies thus far carried out would indicate, therefore, that the inheritance of urediospore colour in crosses between orange and greyish-brown strains may be explained by assuming the presence of two pairs of Mendelian factors, of which one governs the pigmentation of the spore wall, the other the pigmentation of the cytoplasm. If G represents the factor determining the greyish-brown colour of the spore wall and Y the factor determining the yellow or orange colour of the cytoplasm, the constitution of the greyish-brown parental strain would be GGyy and that of the orange parental strain ggYY. The heterozygous red $F_1$ hybrid form would then possess the constitution GgYy. Selfing of the $F_1$ hybrid form would then result in $F_2$ progeny of the following genotypic constitution and breeding behaviour.

| Urediospore colour in $F_2$ | $F_2$ genotype | $F_3$ progeny |
|---|---|---|
| Red | GGYY | Red |
| Red | GgYY | Red and orange |
| Red | GGYy | Red and greyish-brown |
| Red | GgYy | Red, greyish-brown, orange, and white |
| Greyish-brown | GGyy | Greyish-brown |
| Greyish-brown | Ggyy | Greyish-brown and white |
| Orange | ggYY | Orange |
| Orange | ggYy | Orange and white |
| White | ggyy | White |

It should be pointed out that the scheme of colour inheritance advanced above must be regarded as more or less provisional as it has not been experimentally confirmed in all its details. In a number of selfing experiments the ratios between the different colour groups have failed to approximate Mendelian ratios. However, the lack of agreement with Mendelian ratios may perhaps, in these instances, be ascribed to the smallness of the populations studied.

## SUMMARY

1. Selfing studies have been made on a number of $F_1$ hybrid forms and $F_2$ cultures of crosses between physiologic forms of *Puccinia graminis tritici*.

2. In the selfing of an $F_1$ hybrid form segregation and subsequent recombination of the factors governing pathogenicity lead to the production of an $F_2$ population comprising several different physiologic forms among

which the original parental forms are frequently found. The number of physiologic forms present in the $F_2$ generation is definitely greater in some crosses than in others, indicating that the same number of factors is not involved in all crosses.

3. Selfing studies on $F_2$ cultures of several crosses have shown that some of the $F_2$ cultures are homozygous but the majority are heterozygous for pathogenicity. The progeny of a heterozygous $F_2$ culture generally contains fewer physiologic forms than that of an $F_1$ hybrid form.

4. In a previous paper certain pathogenic differences noted in $F_1$ hybrid forms originating from opposite sides of reciprocal crosses were attributed to the influence of the cytoplasm. These pathogenic differences have persisted in all the individuals of the $F_2$ and $F_3$ generations and do not, therefore, appear to be subject to segregation and recombination as are other pathogenic characters in the same crosses. These results appear to support the original assumption concerning the influence of the cytoplasm.

5. Although the inheritance of urediospore colour has not been worked out in all its details, there is every indication that it is Mendelian in character. The factors for orange and greyish-brown pigmentation are, in a sense, complementary factors, and the inheritance appears to be analagous to the well known Rose and Pea comb type of inheritance in fowls. Red spore colour appears to be due to the presence of two dominant factors for orange and greyish-brown. White spore colour may be explained by the presence of their recessive allelomorphs.

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# THE BALSAM WOOLY APHID, *ADELGES PICEAE* (RATZ.) IN CANADA

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[Received for publication January 16, 1934]

## INTRODUCTION

When the study of this insect in the Maritime Provinces was first commenced in 1931 it was largely devoted to an explanation of the so-called "gout disease" of balsam fir (*Abies balsamea* (L) Miller), the cause of which was then unknown. Owing to the fact that this condition had attracted the attention of several investigators (*8*, *7*, *3*) and was causing concern to pulp companies, one of which had employed a pathologist to study it, a brief account of the insect and how it brought about the "gout" was published in 1931 (*2*). Work on this problem has continued since then, and as a number of enquiries have been received from Canada and the United States it is thought advisable to record some further results at this time. As certain phases of the study need several years to complete, a full technical account will be prepared later.

## THE NAME

Previously, this species has been placed in the genus *Dreyfusia* Borner. Annand, however, has put forward good reasons for the reduction of the genera of the Adelginae to *Adelges* and *Pineus* (*1*). This arrangement is followed and the scientific name becomes *Adelges piceae* (Ratz.). The common names in use are: balsam woolly aphid, balsam bark louse, balsam chermes and (in Europe) silver fir chermes. The first is considered preferable.

## HISTORY IN EUROPE

The species has been studied in Germany, France, Denmark, England, Switzerland and Russia, but the literature will not be fully reviewed here. The most complete study is that of Marchal (*10*), who in 1913 reviewed the previous work and described careful experiments elucidating the life history. There is a good deal of confusion in the literature owing to the fact that there are two very similar forms which were not separated until 1904 and were both considered to be *Chermes piceae* as described by Ratzeburg in 1843. Several workers since then have brought evidence that there are two closely related species, separable biologically and morphologically. These species, *Adelges piceae* (Ratz.) and *A. nusslini* (Borner), are now generally accepted, but some writers consider that they may be simply biological races (*5*, *4*).

A disease of fir, chiefly exotic species, consisting of swellings of the buds and twigs, was described in Europe at different times but the cause was unknown until 1903 (*11*). In that year, Cholodowsky gave the name *Chermes piceae* var. *Bouvieri* to what he considered to be a variety of *piceae* which he found to be the cause of this condition. It has been shown that *piceae* will bring about these swellings whenever it attacks certain species of *Abies* and the name is obsolete.

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Reports of European writers differ somewhat as to the amount of damage done by *A. piceae*. Some consider that it does not kill trees, others note that it sometimes kills occasional trees by attacking the stem. It seems to be generally agreed, however, that the serious damage to fir from chermes attack is caused by *A. nusslini*, which is found mostly on the twigs, and which is frequently referred to as doing widespread damage, particularly to young plantations.

There is again, however, some difference of opinion as to whether the dying of fir (mostly *A. pectinata*) is the result primarily of attack by the insect, or results from other causes such as poor soil conditions, the insect being secondary. Schubert (*13*) quotes Professor Bernhard as saying that fir in Saxonia is "not a dying tree, but is already extinct". He says that similar, though not quite as serious, conditions obtain in many other provinces and puts forward evidence that poor soil conditions, associated with acidity, are the real cause of this. Chrystal (*5*, *6*), while not questioning the insect's responsibility, notes that in Denmark the injury is greatest on poor soils.

Conditions apparently vary at different points on the continent as well as with local differences of site, age, etc. This may explain, for instance, why Schneider-Orelli (*12*), working in Switzerland, recommends growing fir in shade, and Chrystal and Boas (*6*, *4*) from observations in the British Isles and Denmark recommend thinning to let in the light. Also, there are differences of opinion as to the behaviour of the two species. Most writers speak of *nusslini* and *piceae* being found in close association on the same trees while Schneider-Orelli (*12*) states emphatically that while they occurred in the same stands they were never found together on the same trees, although a careful study was made over a period of two and one-half years.

There are frequent references to *A. piceae* as the "stem form" and *A. nusslini* as the "twig form" ,and it has been considered by some authors that *piceae* tends to be confined to the stem while *nusslini* is confined to the twigs. Others have shown, however, that both species may occur on the twigs and on the stem of quite large trees. Although there does seem to be a preference for these respective points of attack it is not sufficiently strong to be used even as an aid in separating the two species.

## History in North America

Kotinsky (*9*) reported finding *piceae* killing trees in New Hampshire in 1916. The determination was apparently carefully made. He states, also, that he examined material collected by Hopkins at Brunswick, Me., in 1908 and determined it as the same species. At the same time he secured egg masses and adults from twigs collected by Felt on imported specimens of *A. nordmanniana* in 1910. These he considered to be *nusslini* but the determination was provisional as he apparently did not examine the neosistens and seems to have based his determination on the fact that the insects were on the young growth.

Annand (*1*) records taking *piceae* from several species of *Abies* in California and *nusslini* in association with it on *pectinata* and *nobilis*.

References to the occurrence of *piceae* in New Haven, Conn., seem to be due to an error in the abstract of Kotinsky's paper in the Review of Applied Entomology where New Hampshire was mistaken for New Haven. Dr.

R. B. Friend, of the Connecticut Experiment Station, states that it has not yet been observed in that state.

During the past two years, Dr. H. B. Peirson, State Entomologist, has reported a number of infestations in Maine and in 1933 Dr. H. I. Baldwin, of the New Hampshire Forestry Department, reported attacks in New Hampshire and Vermont. Other reports have come from New York but their authenticity is uncertain, Material sent to this laboratory from Maine by Dr. Peirson and from New Hampshire by Dr. H. J. MacAloney proved to be *A. piceae.*

In Canada, Swaine (*14*) reported the presence of *piceae* in Nova Scotia in 1929. Since that time the writer has found that it is present throughout the whole of that province and the extreme southern part of New Brunswick. The approximate northern boundary of the infested area is a line drawn from Shediac to Fredericton, along the St. John river to Rosborough and down to the border at Vanceboro. Along the coast and for some 20 or more miles inshore the infestation is practically continuous. As the observer approaches the above line it consists of small isolated centres of concentrated attack. North of the line the insect has not yet been found. Infested material has been received from Prince Edward Island.

It is of considerable interest that this infested area roughly coincides with that of the beech bark scale (*Cryptococcus fagi* Bsp.), another European species of similar size and habits, which is likewise parthenogenetic and wingless, and dependent on the same means of dispersal.

*A. piceae* has been in Nova Scotia for over twenty years. Analysis of trees in Shelburne and Digby counties has shown evidence of attack as far back as 1910. The infestation in eastern Nova Scotia and in New Brunswick is more recent.

While Annand reports and figures *A. nusslini* from California, none of the reports of its presence in the East seem to have been based on examination of the integument. All the material so far examined in the Maritimes has proved to be *piceae,* both in its biology and morphology.

## LIFE HISTORY

As in Europe, the life history is confined to *Abies,* there being no generation migrating to spruce. Although a winged form appears in small numbers it does not settle on our native spruces, or on *Picea excelsa. P. orientalis* has not yet been tried. These are more probably *exules alatae* than *sexuparae* although the author has as yet been unsuccessful in getting them to oviposit on either fir or spruce.

*Hiemosistentes.*—Near Fredericton, N.B., only the first stage larvae (*neosistens*) survive the winter although adult *aestivosistentes* and eggs remain alive and capable of oviposition and hatching for some time after the first low temperatures, surviving even 3° F.

These larvae commence to feed during April, about the time that the first signs of swelling appear in the buds of the balsam fir. Moulting begins around the end of the month, although some individuals are much later and may not start to develop until others have commenced to lay eggs. This is dependent on the temperature at the bark, but also on inherent factors. There are three moults.

Oviposition commences around the middle of May and the eggs start to hatch about the end of the month. Fifty or more eggs may be laid before hatching begins. The adult continues to lay new eggs while the earlier eggs hatch. The total number laid varies greatly. While some may lay close to 200 the average is probably not over 100.

*Progredientes and Alatae.*—The first few eggs of some of the *hiemosistentes* produce larvae of the *progrediens* type which settle mostly on the under sides of the needles and feed through a stoma. Some settle on the axis of the new shoot. They are slightly smaller and do not become highly sclerotized like the sistens type, remaining brownish-red instead of turning black. Their stylets are shorter and no wax pores are visible. They commence to develop immediately into two forms.

One form, found only on the needles, has little or no wax secretion and after the second moult becomes distinctly elongate. The fourth stage is a "nymph" and the fifth a winged adult. Although attempts have been made during three seasons to get these winged forms to settle on native and European spruces or on other firs, they have failed to do so and no eggs have been laid by them.

The other form, found on the new shoots and needles and sometimes on older growth, also has five stages but remains wingless and produces eventually a considerable covering of wax threads. Less than 10 eggs are laid and these produce typical sistentes, some of which are *aestivosistentes.*

These *alatae* and *progredientes* are quite scarce but can be found fairly easily in the forest. Many trees lack them entirely. The tendency to produce them seems to be hereditary but may be discouraged or inhibited on the older parts of the stem, where only the apterous form may survive and is rarely seen. The only European writer who seems to have found these forms of *piceae* is Marchal (*10*), who collected five or six specimens in the field and reared a number experimentally. Some of his winged forms laid eggs on fir and were evidently *exules alatae.*

I have found one typical *progrediens* larva overwintering on the stem of a large tree. This is difficult to explain. When brought inside it developed to the second stage with long wool threads and was evidently of the apterous type.

*Aestivosistentes.*—The great majority of the eggs laid by the overwintering forms produce the *sistens* type of larva which settles on the bark and in a few days becomes black with a fringe of wax plates around the margin and down the mid-dorsal line. These *neosistentes* may be found at any time of the year on any part of the tree from the base of the stem to the end of the new shoots. Only in a few cases have they been found on the needles, and these failed to develop.

These larvae go through a varying period of dormancy of 2 to 6 weeks, or more, after which feeding commences and in about 10 days the adult stage is reached. They are the *aestivosistentes.* They are not as prolific as the previous generation, producing, as a rule, less than 50 eggs and at a slower rate. Most of them live until the cold weather in the fall and many continue to oviposit until permanent freezing temperatures occur. Their eggs produce larvae which hibernate—the *hiemosistentes.*

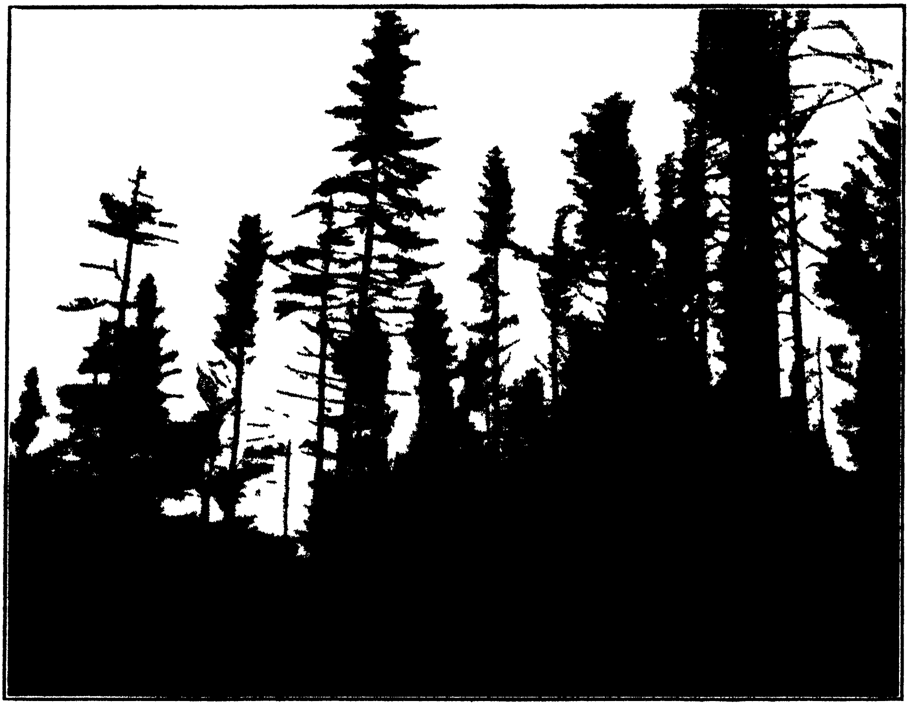

Figure 1 Stand killed by *Adelges piceae* (Ratz.) A number of dead trees cut out on left

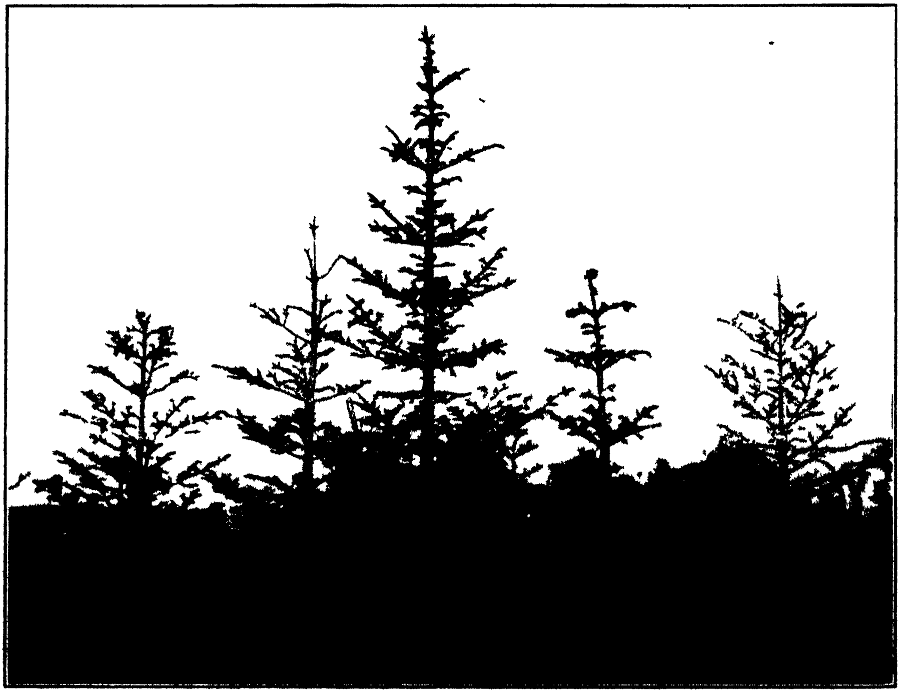

**Figure 2.** Stages in development of "gout", or injury by attack on twigs. Tree on right shows first year, tree in centre third year of attack Note shortening and depression of shoots.

The reproduction of this species is thus seen to be practically confined to two fairly clear-cut generations of *sistentes*. These are recognized at their peaks by the appearance of a noticeable quantity of fresh "wool" on the trees in May and August, when the greatest numbers of adults appear. Later, the wool is to a large extent washed away by rain. There is a period in early July when the population consists almost entirely of larvae, as also during the winter.

Marchal reports two generations of *aestivosistentes* as the rule in France. Two may occur in the Maritimes, but if so, only rarely.

## THE EFFECT ON THE TREE

The *sistentes* have stylets of an average length of about 1.5 mms., sometimes being as long as 2 mms. These are thrust intercellularly into the cortical parenchyma, eventually to their full extent. Apparently a stimulating substance is injected from the salivary glands shortly after the larva settles, as hyperplasia often results even if the larva is killed before it starts to feed.

When feeding commences, the stylets are retracted and protracted in a probing movement so as to reach a considerable number of the cells. The pathway of the stylets is marked by a heavily staining stylet sheath. Cells within or adjacent to this point of feeding undergo some unusual changes. They become enlarged, the walls are usually thickened and often ridged. The nucleus also becomes much enlarged and granular. If the feeding is severe these cells eventually form a pocket of dead material impregnated more or less with resin-like substances. Around this, in the case of *A. balsamea*, a secondary periderm is laid down, generally in the following year, if the attack is not too heavy to prevent it. Layers of purplish cork-like cells are laid down on the inside of the cambium and parenchyma on the outside. Thus, small purple pellets are found inside the cortex which can be lifted out intact from the surrounding parenchyma, abscission taking place outside the cork.

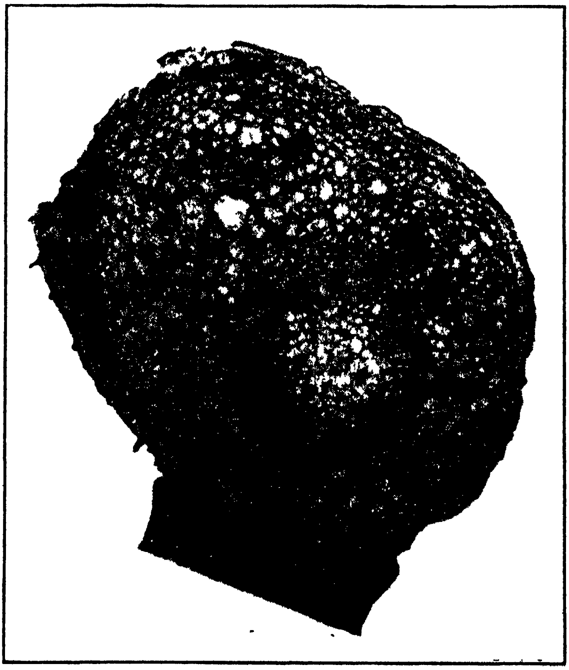

Figure 3. Crossection of one-year old shoot of *Abies balsamea* in winter showing effect of attack since previous spring. Note enlarged cells at older point of feeding. Swelling has ruptured epidermis.

In the case of *A. balsamea, grandis, nobilis*, and *concolor*, an increase in the growth of normal cortical parenchyma cells also takes place around these areas of feeding and this results in the swellings of the shoots and twigs which are known in Nova Scotia as "gout". It also causes a "pimply" appearance on many stems as a result of the preference of the insect for the lenticels or leaf scars. Sometimes the bark of the stem is noticeably thickened and of an unusual spongy texture as a result of heavy attack causing an increased amount of parenchyma and intercellular spaces.

There is at the same time, at least in the case of *Abies balsamea*, a stimulation of the cambium and an increased production of xylem in the neighbourhood of the feeding. The wood is dark, hard and brittle, and consists of cells with heavily thickened walls, similar to those of the "rotholz" produced on the under side of leaning stems. This effect is more or less local and contributes to the swollen appearance.

These swellings appear most often at the buds and nodes which are favourite places of attachment. The amount of swelling depends on the species and the individual tree and the degree of attack. Sudden heavy attack causes little swelling, while one or two larvae may cause a good deal.

Frequently, the buds of attacked shoots fail to develop and the twigs continue to grow in diameter but not in length. Often they gradually die back and after a number of years trees are killed in this way. When the attack is on the trunk, death may result in two or three years. Some trees, however, may carry a light infestation for many years without serious injury while others may support a moderate attack for a long time but in the process become stunted and distorted, generally with a flat top, very rapid taper and a great deal of hard, brittle wood in the outer rings.

In none of the author's experiments has swellings appeared on *A pectinata* although the enlarged cells occur and the tree is gradually killed back. Chrystal (*5*) has studied the effect of *nusslini* on the shoots and found similar enlarged cells. It is of considerable interest that he obtained swellings with *nusslini* on *A. grandis* but not on *A. pectinata* or *A. nordmanniana*. Previously, only *piceae* had been found to cause swollen twigs and Chrystal suggests that this may be evidence that *piceae* and *nusslini* are biological races. Evidently the species of tree is at least as important as the "species" of insect. In the author's experiments, however, *piceae* has caused swellings on *A. nordmanniana*.

Chrystal found that the abnormal cortical tissue partially replaced the xylem in the new shoots, and explained the injury by *nusslini* as a result of interference with the water supply in this way. The author finds that the same thing happens with *piceae* on *A. balsamea* but it is not the main cause of injury.

A detailed discussion of the effects of the insect on the tree will be given in a later publication. It may be said here that the injury results directly from the feeding of the insect and the attendant injection of a substance of the same nature as that which in this group causes gall formation on the spruces. Apparently no microorganism is associated, as has been suggested by some, and the fungi which appear in the bark of dying trees are secondary.

## DAMAGE TO THE FOREST

All sizes and ages of balsam fir are attacked. Severe injury has been found on good sites as well as poor sites, although vigorous trees recover more easily when the insect is removed. Trees in the open and trees in the shade become equally seriously infested when the insects are numerous. There is evidence, however, that some trees are more resistant than others in that a light infestation will rapidly die out on them. Severely injured trees will therefore be found close to others without any injury, particularly where the attack is not aggressive.

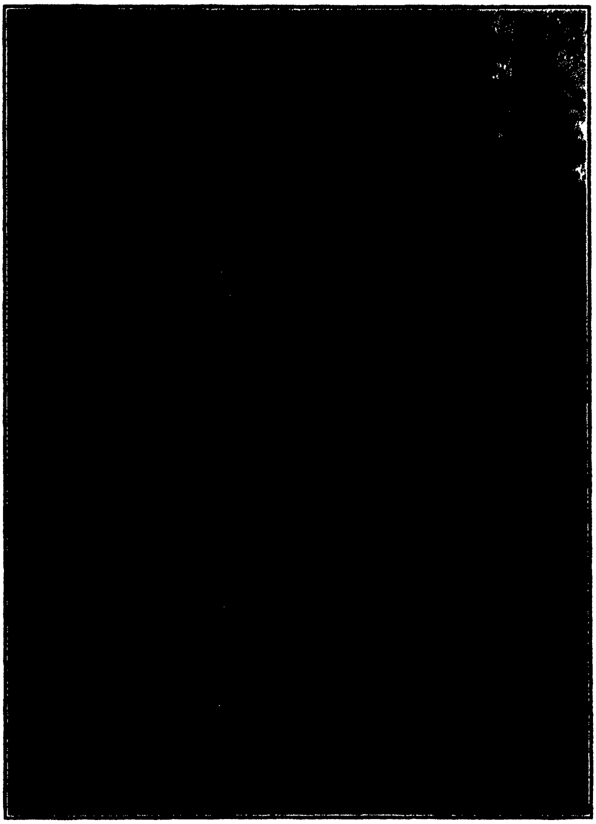

Figure 4. Heavy attack on stem of tree of 9 inches D.B.H.

The injury known as "gout", which consists of swellings and distortions of the twigs and killing of the buds, is characteristic of the older infested areas in Nova Scotia and southern New Brunswick. Throughout this general region hardly any stands are free from it. Some have only slight injury and others have had a number of trees killed, or have up to 75% of the tops dead. This condition results from attack on the twigs over a number of years and there may be associated with it a light and practically invisible attack on the stem.

Here and there are found small centres of heavy attack on the stem where the insects almost cover the bark and the trees are killed often without any appearance of "gout". Sometimes the twigs are completely free from the insect. Such areas are generally less than an acre in size. The attack starts at one point and gradually spreads from tree to tree, sometimes killing the greater part of the stand. The older trees with rough bark are generally attacked first. Small trees beneath them are severely infested and, as a rule, quickly killed by the larvae which fall from the larger trees.

This kind of attack is the one most characteristic of the edge of the infested area where the insect has apparently been recently introduced.

The extent and progress of the damage is being studied by means of a number of permanent sample plots. They indicate a slow but steady deterioration and mortality which are seriously affecting the value of fir as a producer of pulp and lumber.

## SPREAD

The dispersal of the insect, in the absence of winged forms capable of reproduction, takes place in the egg or young larval stage. Once the larva has inserted its stylets it very seldom moves. It is, however, capable under certain circumstances, as are the later stages, of withdrawing its mouthparts and moving to a new location. This, however, is so rare in nature as to be negligible as a source of dispersal.

Experiments have shown that young larvae freshly emerged from the egg are blown considerable distances by strong winds and this is the chief method of dispersal. They are also capable of travelling from one tree to another over the ground and may be carried by man, birds, and squirrels and other animals.

## NATURAL CONTROL

One of the most important factors of control lies in the dying of all the insects on a tree when the tree itself dies.

Direct sunlight kills a good many owing to the heat at the surface of the bark and this is the explanation of the fact that trees with trunks exposed to the sun are free of infestation on the south side. Heavy rain also causes mortality. No evidence has been obtained that low temperature is directly responsible for any mortality although, as mentioned above, it stops development and eventually eliminates all but the *neosistens* larva in early winter.

No parasites are known. A number of native predators feed on the chermes, including syrphids, coccinellids, hemerobiids, an Agromyzid, an Anthocorid, a mite, and a lepidopterous larva, most of which are yet undetermined. None, however, has been found to be an effective agent of control. Some are themselves kept in close check by parasites and birds. Others do not seem capable of breeding up in satisfactory numbers, except on very heavily infested trees where the damage already has been done.

Through the co-operation of Dr. W. R. Thompson, Superintendent of the Farnham House Laboratory of the Imperial Institute of Entomology, the Dominion Parasite Laboratory has secured a considerable number of an Agromyzid, *Leucopis obscura* Trag., from Europe, where it is a valuable predator on *A. piceae*. Mr. A. B. Baird, in charge of the Dominion Parasite Laboratory, has forwarded a number of shipments of adults to New Brunswick where they have been liberated near Fredericton and Gagetown. They have been found overwintering within puparia in very satisfactory numbers.

## ARTIFICIAL CONTROL

An active centre of heavy stem attack may be very satisfactorily checked by cutting the infested trees in winter when there are no eggs or motile larvae. The trees must either be utilized before spring or treated to prevent the larvae developing and laying eggs, as they are capable of doing on a cut tree. Bark scraping or singeing with a slash-burning blow torch will serve this purpose.

It will not be possible, however, to spot all infested trees, and complete extermination is difficult. The method should be attempted only with distinctly circumscribed outbreaks.

On ornamentals, very good control has been obtained by the use of miscible oil sprays thoroughly applied in the late winter or early spring before the first moult takes place. At this time there is less wool to protect the larvae. After they start to develop and cover themselves with wool, the spray is much less effective. Nicotine sprays are not recommended at any time.

## SUMMARY

A brief review is given of the history of *Adelges piceae* (Ratz.) in Europe as it bears on its recent behaviour in North America. The infested area, and the nature and extent of damage in Canada are described. A description and explanation of abnormalities caused by the insect is given. The life history is outlined, together with notes on dissemination, natural control and artificial control.

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# COLOUR STRAINS OF THE DELICIOUS APPLE[1]

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[Received for publication November 15, 1933]

## INTRODUCTION

Within recent years considerable attention has been drawn to the appearance of red strains in several varieties of apples. The occurrence of these red strains is due to bud variations from the original variety. Variations in fruits have probably been occurring for ages, but it is only in the past few years, due to the enterprise of American nurserymen who have advertised several bud sports of important commercial varieties, that their commercial possibilities have become fully appreciated. This publicity has stimulated apple growers in both Canada and the United States to make diligent search for bud variations with the result that surprisingly large numbers have been found. Most of the known bud sports have to do with the colour of the fruit. This is probably due to the ease with which colour variations may be recognized. In the Delicious apple, numerous red bud sports have been found.

The literature contains several papers giving lists of varieties for which "red" sports have been reported (*6*, *7*, *25*). Descriptions of these variations are available. There are also well substantiated reports of bud variations affecting size, shape and russeting of fruits (*10*), also yield and size of trees (*9*, *23*). Detailed field studies have been made by certain workers (*11*). However, a careful search of the literature has failed to reveal any reference to a comparative study of the physical properties and chemical composition of fruit of a bud sport and its parent variety, with the exception of two previous publications from the Summerland Experimental Station, in which some preliminary studies comparing bud variations with their parents are reported (*20*, *21*).

What appear to be four distinct red sports of Delicious have been found in the Okanagan Valley in British Columbia. They occur as individual trees growing in commercial orchards at Salmon Arm, Vernon, Oyama and Winfield, respectively. Definite information as to their origin is lacking. The general indications are, however, that they are bud variations from the ordinary striped Delicious.

Owners of orchards in which these red strains were found reported that the fruit not only developed more red colour but coloured earlier in the season than the striped Delicious. This has been found to be true of other red strains elsewhere (*1*, *6*). It was said the red colour developed irrespective of exposure to sunlight. Since the present system of commercial grading is based largely on the percentage of red colour, it was argued that planting of the new strains would automatically ensure the production of higher percentages of Extra Fancy grade fruit. It was also maintained that fruits of the red strains have a longer storage life and that they may be picked in accordance with their correct ripeness due to the fact that they do not need to be left on the trees until they reach an advanced stage of maturity in order to ensure high colour development.

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[1] Paper based on investigations conducted at the Dominion Experimental Station, Summerland, and the University of British Columbia, Vancouver, during 1930, 1931 and 1932.

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There are, however, several possible disadvantages to this early colouring. Much of the popularity of red apples is due to the fact that high quality is usually associated with red colour. Extensive harvesting experiments carried on at the Summerland Experimental Station and also by other investigators (*16*) have shown that Delicious picked too early in the season develop inferior quality. It is probable that, due to the early colouring of the red strains, they may be harvested too early to allow for full development of dessert quality, with consequent unfavourable reaction on the popularity of the Delicious variety. Thus the question to be answered is: Do the new strains develop full red colour before sugar development and other chemical changes have progressed to the stage necessary to produce superior quality?

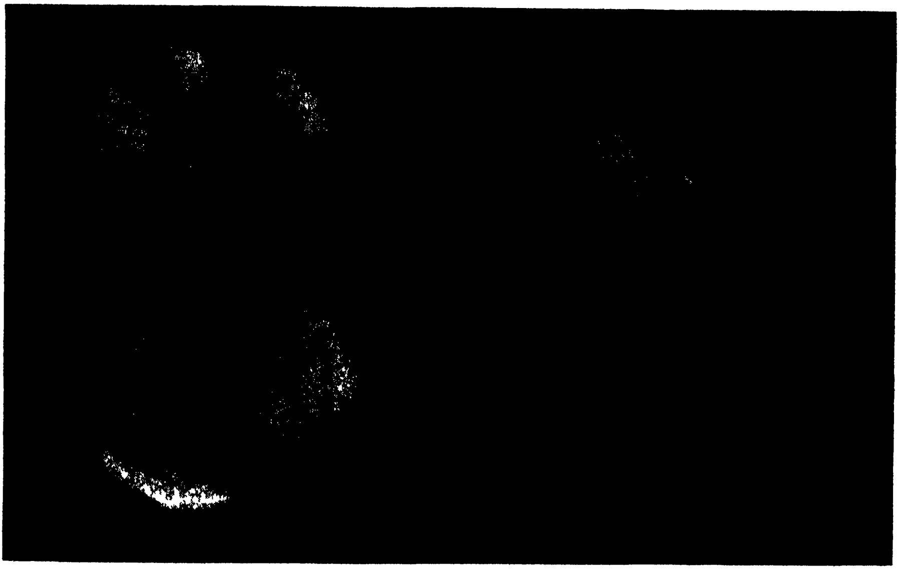


Figure 1. Striped (left) and red (right) strains of Delicious picked on the same date from individual branches grafted on the same tree.

## Purpose of the Work

It was with the above problems in mind that harvesting and storage investigations reported in this paper were undertaken in the autumn of 1930 and continued in 1931 and 1932.

During this time, an attempt has been made to determine any difference physically or chemically between the fruit of the red strains and ordinary Delicious grown under exactly the same conditions and harvested at the same time. A study has been made of the relative storage behaviour of the two strains.

It was realized at the outset that the red sports may differ between themselves as regards colour development and other characteristics. It was further recognized that climatic and soil factors, as well as methods of orchard management, may exert a considerable effect on the chemical composition of fruit. Consequently, it was decided to make tests simultaneously on four red bud sports of Delicious located in commercial orchards in the Salmon Arm, Vernon, Oyama and Winfield districts of British Columbia.

## SOURCE AND DESCRIPTION OF THE FRUIT

The four red strain trees were all comparatively healthy and making good growth The Salmon Arm tree was the oldest, being about twenty years old in 1930, while the Oyama tree was the youngest, being only eight years of age. The Salmon Arm and Vernon trees carried a good crop of fruit in all three years of the investigation. The Winfield and Oyama trees bore moderate crops in 1930 and 1932, but rather light crops in 1931.

The shape of the Delicious apple varied a good deal in the different districts. The fruit of the Winfield and Oyama orchards was often malformed, the apples being stubby and somewhat round, with the five characteristic points indistinct. These abnormalities in shape were apparently due to the soil and climatic conditions, as the fruits of the red and ordinary strains were similarly affected.

In 1932 a small quantity of fruit was obtained from Salmon Arm strains grown on the same rootstock at the Summerland Experimental Station.

## SOIL AND CULTURAL CONDITIONS

The soil in the Salmon Arm orchard is a fairly heavy clay while that in the Vernon orchard is a clay loam. At Oyama and Winfield the soil is a light shaley loam of a coarse sandy nature. Weeds have been allowed to grow up in every one of these orchards, being turned under sometime during the year. The trees in the Salmon Arm locality are non-irrigated, whereas those of the other three districts are irrigated, although the Oyama and Winfield trees seldom received an adequate supply of water. This probably accounts partially for the dullness in red colour of some of the fruit from these latter two districts. The natural precipitation is generally sufficient for the production of good fruit in the Salmon Arm orchard. Likewise more rain and cooler weather are experienced at Vernon than at Oyama and Winfield.

## GENERAL METHODS EMPLOYED

*Methods of Taking and Handling Samples.* For purposes of comparison, a tree of the striped variety of similar age, vigour and yield to the tree of the red strain was selected in each orchard. In 1930 from each of these eight trees, representative pickings were made on October 2, 9 and 16. At each picking, a hundred apples were harvested from each tree, care being taken to pick specimens representative of the colour development of the crop. Although the trees are growing in widely separated districts, it was found possible, by making a 270-mile motor trip, to have one investigator harvest fruit from all the trees and transport it to the Summerland Station on the same day.

The day following each picking, the apples were graded for skin colour, and twenty specimens from each tree tested for hardness and cut to ascertain flesh colour. Forty apples from each tree were held in common storage and another forty were placed in cold storage at 32° F. The cold storage lots were later used for chemical analysis.

In 1931 the complete crop from the eight trees was harvested on October 7 and 8, which dates were considered to be about the commercial picking dates for this variety. This was done in order to obtain sufficient material to make extensive tests of flesh colour as a maturity index and also to secure information regarding skin and flesh colour correlation. The fruit was handled as in 1930 with the exception that a much larger number of graded apples were cut to ascertain flesh colour, and greater quantities were placed in cold and common storage. Analyses were made of the apples of the different flesh colour grades.

In 1932 representative pickings were made of the Vernon and Oyama fruit on October 3, 10 and 17. Particular care was taken with these samples and it might be well to note here exactly how the pickings were made. On the first two dates, twenty apples were picked from the five sections of each tree—north, south, east and west, and the top portion– making a total of one hundred specimens from each tree. On the third picking, forty apples were taken from each part, as above described. Wherever possible, the twenty or forty specimens of each section were picked from the one limb. By taking representative samples in this manner, it was planned to eliminate as far as possible both the personal element and the variance naturally occurring in the fruit on the tree. At Salmon Arm and Winfield the complete crop was harvested on October 6 and 7 respectively. Numerous apples from the strains in these two districts were graded for flesh colour and analyzed. On the whole the fruit was handled as in the previous years and similar tests were made. However, a portion of a representative sample of the Vernon and Oyama fruit was analysed immediately on picking, the rest being stored at 32° F. and later removed to a ripening room for analysis in an eating ripe condition.

Also, in 1932, representative pickings were made on September 23 and 30, and October 14, of Salmon Arm red Delicious and ordinary Delicious, grown on the same rootstock at this station. These apples were analyzed at picking time. A small portion of the third picking, however, was cold stored and later analyzed when it had reached eating ripe condition.

In all three seasons, wherever possible, all pickings, records, and grading were done by the same individual in order to eliminate the personal factor as much as possible and to ensure comparable treatment of the fruit from all trees.

*Examination for Inherent Tree Characteristics.* A careful examination was made of the characteristics of trees of the red strains growing on clonal root systems to determine if they differed from one another or from the ordinary striped variety in such characters as foliage, colour of bark, numbers and form of lenticels, etc.

*Methods of Chemical Analysis.* The following chemical analyses were made on the fresh expressed juice each year: total sugars, reducing sugars, sucrose as invert, total acid, specific gravity, and Brix hydrometer reading. The percentage dry matter of the fruit was also determined in all cases. In 1930, sugar determinations were checked by analyzing alcoholic extractions of the apple tissues. In 1931 and 1932 the sugar and acid determinations were checked by analyses carried out on pasteurized samples of juices (*8*).

Conductivity values were determined in 1930; hydrogen ion or pH determinations were made in 1930 and 1931; the juice was analyzed for tannin in 1931 and 1932; respiration and water evaporation loss tests were conducted in 1931 and 1932.

For the expressed juice determination, care was taken to obtain uniform samples of juice. Twenty to thirty apples were quartered, the seeds discarded, and opposite quarters were passed through a common food chopper. Samples for dry weight and nitrogen determination were taken from this thoroughly mixed pulp. The pulp was then placed in a hand power press and the juice expressed. The analyses were begun immediately. The alcohol sugar extracts were obtained by extracting similar portions from each of six to eight representative specimens. Several methods in use for sugar determinations were tried. Benedict's volumetric method (*13*) and Shaffer and Hartmann's iodometric method (*24*), the latter proving somewhat superior to the former, were found to give good results, and were used in the early part of the work. However, the more recent method of Lane and Eynon (*14*) which has been adapted to analysis of sugars in apples by Evans (*12*) was the most satisfactory and was used entirely during the last year and one-half of the investigation.

For the estimation of free reducing sugars, the juice was clarified with neutral lead acetate and alumina cream, the surplus lead being removed with a saturated solution of sodium oxalate. Total sugars were determined upon a portion of the clarified solution by inverting with citric acid and employing the same method as for reducing sugars. When the Shaffer-Hartmann method was employed, hydrochloric acid was used for inversion.

Total titratable acidity, tannin, and nitrogen were determined according to the methods of the Association of Official Agricultural Chemists (*4*). The hydrogen ion (determined electrically with a Leeds and Northrup quinhydrone indicator) and the electric conductivity measurements (determined with a Leeds and Northrup potentiometer) were made on the freshly expressed juice. To determine the dry weight, 50 gms. of the sample of pulp were weighed into a tared metal dish, and dried in a well ventilated electric oven at 100° C. for 36 hours (*2*). Archbold (*3*) has recently found that slightly greater loss of weight than that due to the evaporation of moisture is obtained by this method owing to the decomposition of the sugars.

*Method of Determining Rate of Respiration and Evaporation Loss of Fruit.* The method of determining the rate of respiration of the fruit was essentially that used and described by Magness and Diehl (*15*). The carbon dioxide absorbed in the potassium hydroxide solution was measured by titrating 10 cc. aliquots of the potassium hydroxide solution according to the method of Blasdale (*5*). All determinations of the rate of respiration were made on fruit of Extra Fancy colour and medium size grade which had been previously held at 32° F. for about two months. The evaporation loss of the fruit was determined according to the method of Markley and Sando (*18*). Fruit of various size and colour grades which had been in cold storage for approximately two months was used in the tests.

## PRESENTATION OF RESULTS

Data, both chemical and physical, obtained in the course of the investigation, are summarized and presented in tables throughout the accompanying discussion of the results. The comparisons are all made of the red and striped strains growing in the same orchards under similar conditions.

*Hardness and Ground Colour of Fruit at Picking.* Pressure determinations made with a mechanical pressure tester (*17*) did not reveal any significant difference in hardness between the red and striped strains grown under similar conditions. Hardness varies to some extent with colour and size grades. The smaller apples generally test higher than the large ones. Early in the picking season, Extra Fancy fruit may test harder than C grade, but again later in the season, C grade fruits may test higher than Extra Fancy.

The use of a ground colour chart, as a maturity index, was of little value with the new strains owing to the occurrence of red colouring over the entire Jonathan variety (*19*). However, in 1930 the maturity colour chart previously devised for use in harvesting the Jonathan variety (*19*) was tested on Delicious by using specimens which had some unblushed surface. The results recorded were in fair agreement with those obtained from other tests the same year.

*Skin and Flesh Colour Grading of Delicious Strains. Skin Colour.*—There was a marked difference in time and amount of red colour development. By having the same observer grade all the apples in this experiment into three classes to conform with the Canadian Government requirements for Extra Fancy, Fancy and C grade Delicious, which are: over 60%, 25 to 60%, and under 25% red colour, respectively, it was possible to secure comparable data. Some results of grading the 1930 crop are presented in Table 1.

TABLE 1 – COLOUR GRADING OF DELICIOUS STRAINS

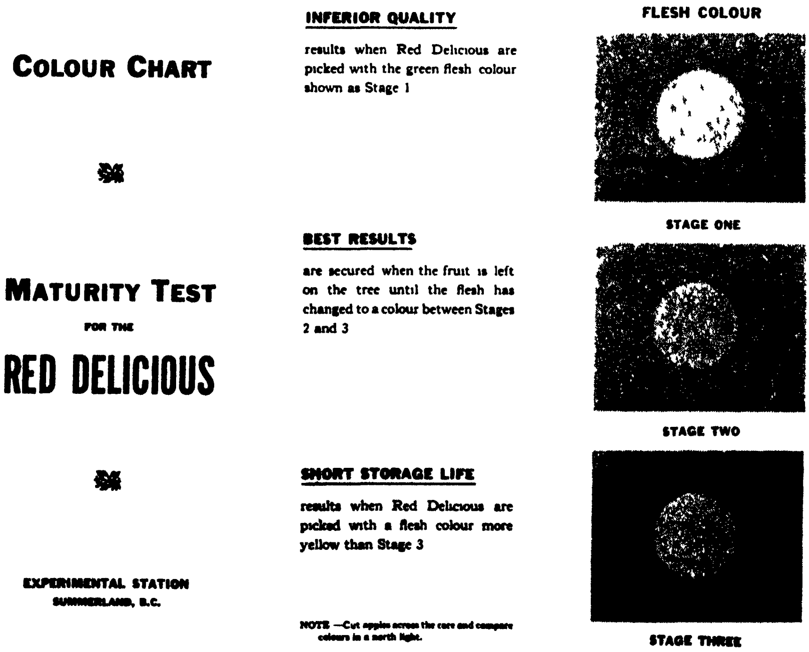
| Picking date | Percentage extra fancy grade fruit | |
|---|---|---|
| | Red strains | Striped strains |
| October 2 | 83 | 5 |
| October 9 | 90 | 22 |
| October 16 | 94 | 45 |

The figures incorporated in the above table indicate the percentage of fruit with Extra Fancy colour, harvested from the striped and red strain trees at each picking date. It will be noted that the new red strains coloured earlier. The results of three years' investigations show that they grade for red colour 70 to 80% Extra Fancy from one to two weeks before 50% of the crop of the ordinary striped Delicious grade Extra Fancy.

As may be expected, there is some variance in the amount of red colour development in both red and striped strains on any one date from year to year. Also there is a slight variance in the amount of red colour developed by the different red strians. The Vernon sport had not in any year on the same date as high a percentage of red colour as the others. The greater percentage of Extra Fancy grade fruit found in both strains at Oyama and Winfield in two of the years was probably due to the locality, soil and moisture conditions. There was a pronounced difference in quality of colouring in the individual red strains, fruits from the Salmon Arm and Vernon trees developing a bright scarlet colour, whereas those from Oyama and Winfield became a deep mahogany red.

Since most growers are well satisfied when half their crop of striped Delicious qualifies as Extra Fancy, it seems altogether probable that they are likely to pick the red strains at an earlier date than has been customary with the striped Delicious. That such a procedure may react to their disadvantage is shown by determinations of flesh colour, quality and chemical composition.

*Flesh Colour.*—As Delicious approach maturity on the tree, the flesh colour changes from a distinct green to a creamy yellow, passing through an intermediate stage of almost white colour. These flesh colours, going from green to yellow, are similar, though not identical, to Pale Chalcedony Yellow, Marguerite Yellow and Naphthalene Yellow as shown in Ridgway's Colour Chart (*22*). Data on the flesh colour of the fruit were secured by cutting across a number of apples from each picking from each tree and grading into three flesh colour classes, designated "green", "white", and "yellow". (See facsimile of colour chart, Figure 2.)



**COLOUR CHART**

**MATURITY TEST**

FOR THE

**RED DELICIOUS**

EXPERIMENTAL STATION
SUMMERLAND, B.C.

**INFERIOR QUALITY**

results when Red Delicious are picked with the green flesh colour shown as Stage 1

**BEST RESULTS**

are secured when the fruit is left on the tree until the flesh has changed to a colour between Stages 2 and 3

**SHORT STORAGE LIFE**

results when Red Delicious are picked with a flesh colour more yellow than Stage 3

NOTE.—Cut apples across the core and compare colours in a north light.

FLESH COLOUR

STAGE ONE

STAGE TWO

STAGE THREE

Figure 2. Facsimile of Flesh Colour Chart.

In Table 2, some of the data for the 1930 crop are summarized. They are indicative of the results secured in the following years.

TABLE 2.—FLESH COLOUR GRADING OF DELICIOUS STRAINS

| Picking date | Percentage of fruit, with green flesh colour | |
|---|---|---|
| | Red strains | Striped strain |
| October 2 | 25 | 31 |
| October 9 | 20 | 16 |
| October 16 | 11 | 7 |

From the data presented in Table 2, it is apparent that the highest percentage of green-fleshed fruit in both strains appeared in the early pickings and decreased materially over the two weeks.

Flesh colour varied somewhat with size, but particularly with skin colour. In order to secure evidence regarding the correlation of flesh colour and skin colour, the same fruits which were cut across to determine flesh colour, were also graded for skin colour. Summarized data regarding the correlation of skin and flesh colour are recorded in the following table.

TABLE 3.—CORRELATION OF SKIN COLOUR AND FLESH COLOUR

| Flesh colour | Percentage of extra fancy fruit | |
|---|---|---|
| | Reds strains | Striped strain |
| Green | 28 | 0 |
| White | 32 | 32 |
| Yellow | 40 | 68 |

From Table 3 it is evident that by grading for skin colour in the ordinary Delicious, almost all of the green-fleshed fruits were placed in the C grade, whereas in the case of the red strains, 28% of the green-fleshed fruits developed sufficient red colour to qualify for the Fancy and Extra Fancy grades. Thus, grading for red colour practically eliminated the green-fleshed fruits from the Extra Fancy grade in the case of the striped Delicious, but not in the case of the red strains.

The significance of the fact that the red strains develop red skin colour before their flesh colour has progressed to the white or yellow stages, was revealed by quality determination during the storage period and by sugar analysis of the flesh colour grades. While the green flesh colour tends to bleach out somewhat after the fruit is picked, it was, nevertheless, found possible to grade stored samples into green, white and yellow flesh colours at the time when the fruit was considered to have reached prime eating condition. Since quality, as applied to apples, involves so many characteristics, and as the tastes of individual consumers differ, it is not easy to devise a satisfactory scale of quality. However, a record of the comparative excellence of a number of individual specimens was secured by classifying them as "good", "fair" and "poor". Several specimens from each tree from each picking were sampled by the same observer. It was found in the two years in which three pickings were made over a period of two weeks, that the percentage of good quality fruit was higher in the second picking than in the first, and higher in the third than in the second. However, there was a wide range in quality even in apples picked from the same tree on the same day, especially in the first pickings. The correlation between flesh colour and quality, on the other hand, was found to be very close, most of the apples having green flesh colour being classed as poor in quality. The yellow-fleshed specimens on the whole developed the best quality. This suggests that early picking of the red strains may give apples of Extra Fancy skin colour but only C grade dessert quality.

*Analytical Data. Sugar Content.*—It was found that the red strains and ordinary Delicious maturing on comparable trees developed sugar at the same rate and in equal quantities with only very small variations. The early red colouring in the new strains was not accompanied by an early accumulation of sugar. Evidence substantiating this appears in Tables 4 and 5. They show that the red and ordinary Delicious from any one district had practically the same sugar content when harvested on the same date. The Salmon Arm red strain usually showed a slight indication toward a higher sugar content than the striped Delicious grown under similar conditions even when both strains were grown on the same rootstock at the Experimental Station, although in this latter case the difference is negligible and the results of only one year are obtainable. There is greater variance between the strains in the first year's results than in the following seasons. Moreover, variation in sugar content was not consistent each year, opposite results being secured in 1930 and 1931, whereas both strains from any one district had almost identical sugar contents in 1932. From Table 4 it is readily seen that the sugar content of ordinary striped Delicious varied to a great extent from one district to another and from year to year, whereas there was no significant difference in sugar content between red and striped strains grown in the same orchard under similar conditions and harvested at the same time.

TABLE 4—TOTAL SUGAR CONTENT OF DELICIOUS STRAINS

| Source of fruit | Year | Percentage sugar in fruit | |
|---|---|---|---|
| | | Red strains | Striped strain |
| Salmon Arm | 1930 | 16.3 | 15.3 |
| Vernon | | 13.3 | 12.1 |
| Oyama | | 11.3 | 12.5 |
| Winfield | | 11.6 | 11.6 |
| Salmon Arm | 1931 | 13.40 | 13.04 |
| Vernon | | 11.60 | 12.78 |
| Oyama | | 13.64 | 13.55 |
| Winfield | | 14.71 | 14.69 |
| Salmon Arm | 1932 | 14.48 | 14.92 |
| Vernon | | 10.93 | 10.90 |
| Oyama | | 10.93 | 10.46 |
| Winfield | | 11.26 | 11.73 |
| Experimental Station (Salmon Arm Strain) | | 13.23 | 13.00 |

The figures incorporated in Table 4 give the percentage of sugar in the red and striped strains of Delicious at the commercial picking time for ordinary Delicious in each of the three years of the investigation.

In Table 5, the close agreement in sugar content of the red and striped strains is further demonstrated. Also it is shown how the percentage sugar in the fruit gradually increased at the same rate in both the red and striped strains as the season advanced. This increase in total sugars was due primarily to an increase in sucrose.

TABLE 5.—INCREASE IN SUGAR CONTENT OF DELICIOUS STRAINS

| Source of fruit | Percentage of sugar in fruit at each picking date | | | | | |
|---|---|---|---|---|---|---|
| | Red strains | | | Striped strain | | |
| | Oct. 3 | Oct. 10 | Oct. 17 | Oct. 3 | Oct. 10 | Oct. 17 |
| Vernon | 10 54 | 10 93 | 11 28 | 10 23 | 10 90 | 11 28 |
| Oyama | 10 27 | 10 93 | 11 35 | 10 11 | 10 46 | 11 41 |
| *Experimental Station (Salmon Arm Strain) | 10 83 | 11 60 | 13 23 | 10 79 | 11 37 | 13 00 |

*This fruit was picked on Sept. 23, 30, and October 14 respectively.

Slightly greater variance was found between the two strains in the first picking of the 1930 crop, the red strains with the exception of the Salmon Arm one, being somewhat lower in sugar content than the ordinary Delicious. This is probably due to the fact that elimination of the C grade fruit that year from the samples used for analysis removed the green-fleshed apples from the striped but not from the red strains. Data substantiating this statement are to be found in Table 6.

The results of analysis of fruit having green, white and yellow flesh colours are presented in Table 6. This analysis shows the fruits having these various flesh colours had a definite range in sugar content increasing appreciably as the colour of the fruit changed from green to yellow. It is apparent that there was no material difference in sugar content between red and striped strain fruit of the same flesh colour grade, whereas on the other hand, fruit of white flesh colour had significantly greater sugar content than fruit of green flesh colour, and fruit of yellow flesh colour had significantly greater sugar content than fruit of white flesh colour. The increase in total sugar of the yellow-fleshed fruit was due mainly to an increase in sucrose.

TABLE 6.—SUGAR CONTENT OF FLESH COLOUR GRADES

| Flesh colour grade | Percentage sugar in fruit | |
|---|---|---|
| | Red strains | Striped strain |
| Green | 12 44 | 12.67 |
| White | 12.91 | 13.26 |
| Yellow | 13.55 | 13.59 |

*Acid Content.*—The acidity varied but there was no consistent difference between red and striped strains with the possible exception of the Vernon red Delicious which showed a tendency to be slightly higher in total acid content than the ordinary striped type. The acidity decreased slightly by the end of the third picking in all strains, with the exception of the Vernon strains in 1932. Also fruit of yellow flesh colour showed a slightly lower acid content than fruit of green flesh colour.

There was no consistent difference between the red and ordinary Delicious in respect to hydrogen ion concentration and conductivity values. The pH averaged each year around 4.0 to 4.1 except in a few cases when the determinations were made on some very ripe samples. It was hoped by electrical conductivity tests to secure information regarding the comparative amounts of inorganic constituents present in the expressed juice, but the results were so inconsistent that these analyses were discontinued after the first season.

A few titration curves were constructed which showed the buffer action of the red and striped strains to be similar.

No significant or consistent differences were found between red and striped strains in the amounts of tannin and nitrogen present in the fruit. As great differences were noted between fruits of the striped strain from the several districts as between the two strains in the same orchard. Both the red and striped strains were rather low in tannin content, the juice containing usually 0.03 to 0.04% tannin. The nitrogen content of the flesh of the apples also ranged from about 0.03 to 0.04%.

Dry matter determinations were found to be an indication of the percentage sugar present in the apples. Specific gravity and Brix hydrometer readings served the same purpose.

*Storage Behaviour.* Information regarding the keeping qualities of the various strains was secured by examining the fruit held in common and cold storage when it had reached eating ripe condition. The hardness determination and maturity tests made by tasting the fruit showed no material difference in keeping quality between the red strains and ordinary Delicious grown under the same conditions and harvested at the same stage of maturity. Likewise, red and striped strains developed similar flavour and eating quality. A few samples of apples from all the strains were held continuously from time of picking till the middle of April at 32° F. They all kept well and by the latter part of April were still in good eating condition.

*Analysis of Apples at the End of Storage.* Complete analysis of apples at the end of storage in an eating ripe condition was obtained for the 1932 crop. The results of this analysis substantiate the data presented above with respect to the keeping quality of the red and striped strains. The analysis strongly indicates that the red and striped strains developed similar sugar and acid content in storage. There was an increase in total sugar and a decrease in total acid from the fruit analyzed at time of picking. It is worth noting that the increase in total sugar was due in the most part to an increase in sucrose. The development of sugar in the fruit during storage is summarized in Table 7.

TABLE 7 —DEVELOPMENT OF SUGAR IN STORAGE

| Source of fruit | Percentage of sugar in fruit | | | |
|---|---|---|---|---|
| | Red strains | | Striped strain | |
| | At picking time | At eating ripe stage | At picking time | At eating ripe stage |
| Vernon | 10 93 | 13 10 | 10 90 | 13 30 |
| Oyama | 10 93 | 11 75 | 10 46 | 12 06 |
| Experimental Station (Salmon Arm Strain) | 13 23 | 15 76 | 13 00 | 16 23 |

*Relation of Skin Colour and Quality.* Table 8 shows the percentage of sugar in the various skin colour grades of the red and striped strains of Delicious apples when in prime eating condition.

TABLE 8 RELATION OF SKIN COLOUR AND SUGAR CONTENT

| Source of Fruit | Strain of Delicious | Skin colour Grade | Percentage | | |
|---|---|---|---|---|---|
| | | | Reducing sugar | Sucrose as invert | Total sugar |
| Salmon Arm | Red | Extra Fancy | 12 05 | 2 33 | 14 38 |
| | Striped | Extra Fancy | 12 39 | 2 43 | 14 82 |
| | | Fancy | 12 00 | 2 38 | 14 38 |
| | | C | 12 00 | 1 91 | 13 91 |
| Winfield | Red | Extra Fancy | 9 75 | 1 20 | 10 95 |
| | Striped | Extra Fancy | 9 97 | 1 86 | 11 83 |
| | | Fancy | 9 81 | 1 16 | 10 97 |
| | | C | 9 67 | 0 88 | 10 55 |

From Table 8 it may be noted that the sugars are higher in the Fancy and Extra Fancy grade fruit. In this table also, it might be observed that the Extra Fancy apples of the red strains had a slightly lower sugar content than the same grade of fruit from the striped strain. This is undoubtedly due to the green-fleshed fruit in the red strains carrying sufficient red colour to qualify for the Extra Fancy grade . As previously mentioned, in the case of the striped strain, these green-fleshed fruits are practically eliminated from the Extra Fancy grade and fall, for the most part, into the C grade.

*Respiration and Evaporation Loss Tests.* The respiration tests showed the two strains to respire at practically the same rate. The evaporation loss of water through the skin, stem and calyx tube of the apples, showed no consistent differences.

*Tree Characteristics.* A careful examination of foliage, colour of bark, lenticels and general appearance revealed no characteristic differences between the red strains themselves nor the ordinary striped variety from which they sported.

Budding of ordinary striped Delicious and the Salmon Arm red strain on a clonal rootstock, No. 227, revealed an interesting difference between these two strains. The striped Delicious buds grew well and produced first grade trees in the nursery, but the Salmon Arm red strain showed unmistakable signs of uncongeniality with this particular rootstock, the young growth dying during the summer (Figure 3). Furthermore, the rootstocks themselves were killed. Death of these roots may have been due to starvation, but the fact that suckers sent up by the rootstocks failed to keep them alive suggests that some toxic substance may have been transferred to the rootstocks from the new growth produced by the red strain buds.

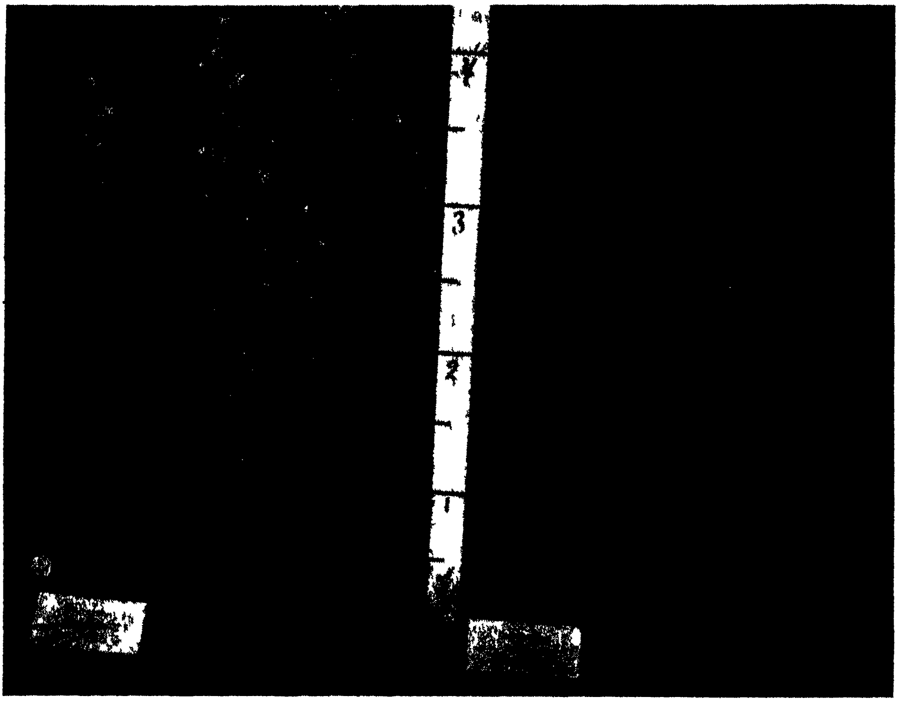


Figure 3. Striped (left) and red (right) strains of Delicious budded on clonal rootstock No. 227. Note that the red strain shows evidence of uncongeniality with this stock.

## DISCUSSION AND CONCLUSIONS

The data accumulated during this three-year investigation of colour strains of the Delicious apple occurring in the Okanagan Valley of British Columbia, suggest the following conclusions.

There are red strains of Delicious which colour earlier and produce a much higher percentage of Extra Fancy coloured fruit than the original striped variety. It is also apparent, from flesh colour determinations and chemical analysis, that this earlier development of red colour is not altogether an advantage. In the ordinary Delicious, red colour has provided a fairly reliable criterion of the quality of the fruit. However, the red colour of these four new strains develops in advance of sugar accumulation. This is decidedly a disadvantage in that high sugar content is a requisite characteristic of prime Delicious, and premature harvesting of the red strains is thus likely to give apples which will meet Extra Fancy colour requirements but be of only C grade quality. For this reason, it is imperative that growers take special precautions to harvest the red strains at the proper stage of maturity to ensure maximum quality. This is the same time for both red and striped strains, namely at the time when about 50% of the striped Delicious grade Extra Fancy.

The flesh colour of the fruit has proved to be a comparatively reliable index of maturity. Flesh colour is easy to determine after a little practise and is readily adaptable to field tests as it is only necessary to cut across and examine a few representative apples from each tree. It is best to examine the flesh colour in a north light. A chart showing three flesh colour stages has been prepared (Figure 2). Evidence has been secured that the time when the flesh colour of the fruit is turning from white towards yellow, is the ideal picking stage.

Red Delicious, picked at the proper stage of maturity, are pleasing to the eye, and develop just as excellent quality as the ordinary striped strain grown under similar conditions. Furthermore at this stage they grade close to 100% Extra Fancy.

## SUMMARY

1. A comparative study, both physical and chemical, was made over a three-year period, of four distinct red bud variations of the Delicious apple and the ordinary striped strain from which they originated.

2. The new red strains coloured earlier and to a greater extent than the ordinary Delicious. This red colouring developed to some extent irrespective of exposure to sunlight.

3. The results of pressure tests, pH, conductivity, tannin and nitrogen determinations, titration curves, respiration and evaporation loss tests, revealed no significant differences between the red and striped strains.

4. The early red colouring in the new strains was not accompanied by an early accumulation of sugar. In other words, high colour is not necessarily associated with a high sugar content.

5. The fruit of the red strains and ordinary Delicious maturing on comparable trees, developed sugar at the same rate and in equal quantities with only very small variations.

6. The acidity varied but there was no consistent difference between red and striped strains.

7. There was no material difference in keeping quality between the strains. Grown under uniform conditions, the red and striped strains developed similar sugar and acid content in storage. Total sugar increased up to a certain point while total acid gradually decreased.

8. Flesh colour was found to be a reliable index to maturity. The three flesh colours, designated "green", "white", and "yellow", were compared with colours in Ridgway's Colour Chart, and found to be similar, though not identical to, Pale Chalcedony Yellow, Marguerite Yellow and Naphthalene Yellow, respectively.

9. Fruit of yellow flesh colour was higher in sugar content than fruit of white flesh colour, and fruit of white flesh colour was higher than that of green flesh colour. The increase in total sugar going from green to yellow-fleshed fruit was due mostly to an increase in sucrose.

10. Green-fleshed fruit developed poor quality, whereas the yellow-fleshed specimens on the whole developed the best quality.

11. The highest percentage of green-fleshed fruit appeared in the early pickings and decreased materially over each succeeding week. Furthermore, in grading for skin colour in the ordinary Delicious, almost all of the green-fleshed fruits were placed in the C grade, whereas in the case of the red strains, many of the green-fleshed fruits developed sufficient red colour to qualify for the Fancy and Extra Fancy grade.

12. Extra Fancy grade fruit of both the red and striped strains of Delicious had a higher sugar content than the C grade fruit. Also the Extra Fancy apples of the red strains showed a slightly lower sugar content than the same grade of fruit from the striped strain, due, in all probability, to the green-fleshed fruit in the red strains.

13. Tree growth characteristics were similar in all strains, but propagation of red and striped strains on a clonal rootstock revealed a difference in congeniality with this stock.

## ACKNOWLEDGMENTS

The writer is deeply indebted to Mr. R. C. Palmer, Superintendent of the Dominion Experimental Station at Summerland, B.C., who originally proposed and commenced this investigation, for his very material aid and many timely suggestions freely given during the entire progress of the work; and to Dr. G. H. Harris, Assistant Professor of Horticulture, at the University of British Columbia, who gave much valuable assistance and many helpful suggestions during the early part of the project. Acknowledgment is also made to Mr. F. N. Hewetson who conducted the rootstock propagation trials.

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# THE ECONOMIC SITUATION

PREPARED IN THE AGRICULTURAL ECONOMICS BRANCH, DEPARTMENT OF AGRICULTURE, OTTAWA, FROM BASIC DATA COLLECTED BY THE DOMINION BUREAU OF STATISTICS

The usual discussion of the economic situation as revealed by current index numbers of prices and production, supplemented by other statistical data has been omitted from this issue although the indexes for the month of January have been added. This has been done in order to focus the attention of the readers of *Scientific Agriculture* upon the fact that a somewhat comprehensive analysis of the Agricultural Situation has been prepared by the officers of the several Branches of the Department of Agriculture, the Commercial Intelligence Service, and the Dominion Bureau of Statistics. This first review, which it has not been possible to issue at an earlier date, will be available shortly after the first of March. It is intended that the report will be made annually and distributed in time to be used as a basis for production planning. It will be realized that the references given here are very brief and that the complete statement should be read in order that the full weight of the different factors may be more apparent.

*Domestic Demand.*—In regard to Domestic Demand the report states: "Recent improvement in general business conditions in Canada gives ground for some degree of confidence with regard to the domestic market for Canadian farm products. Present indications do not warrant any expectation of a rapid rise in prices of agricultural produce. Nevertheless there has been some advance in recent months after a period of almost uninterrupted decline. Certain developments support the view that the demand for the farm products of Canadian farms should show moderate improvement in the immediate future." Among these are the substantial rise in the indexes of wholesale prices in general and of Canadian farm products, a steadily increasing volume of industrial production, improved employment conditions, fewer business failures, lower storage stocks of agricultural products, and some increase in retail sales.

*Foreign Demand.*—In the analysis of foreign demand emphasis is placed upon the fact that 70% of our exports of agricultural products were marketed in the United Kingdom in 1933. The recent improvement in employment and business activity along with the building and reconstruction programmes under way gives hope of some improvement in this market in 1934. What is true of United Kingdom is also true of most continental countries, though the disturbed international political situation is recognized as an unfavourable factor. The tendency to nationalistic trade barriers in the form of tariffs, price fixing agreements, quotas and exchange controls is also regarded as one of the less favourable signs. It is pointed out, however, that the extent to which such barriers curtail international trade is being more generally recognized and this is a favourable sign although it is believed that the withdrawal of such impediments to trade must be gradual. In general, foreign competition will continue to be intense though rising world prosperity would remove some of the causes of protective measures for farmers and gradually some of the forces which at present make for extreme competition.'

*Grains.*—Four years of relatively low prices has not materially affected the total acreage sown to grain in Canada. There has been a noticeable shift from the production of barley, rye, flax, and buckwheat to wheat, oats, and corn. "With the exception of wheat, stocks of grain will be relatively low at the end of July. As long as a wheat surplus persists in Canada, farmers should consider the possibilities of marketing the lower grades through live stock. Wide spread drought during recent years has indicated the advantage of maintaining a reserve of feed grains and odder on the farm. In view of an existing surplus of wheat, a portion of the land normally

## ANNUAL AND MONTHLY INDEX NUMBERS OF PRICES AND PRODUCTION COMPUTED BY DOMINION BUREAU OF STATISTICS

| Year | Wholesale Prices 1926 = 100 | | | | Retail prices and cost of services (5) | Production (6) 1926 = 100 | | | |
|---|---|---|---|---|---|---|---|---|---|
| | All commodities (1) | Farm products (2) | Field products (3) | Animal products (4) | | Physical volume of business | Industrial production | Agricultural marketings | Cold Storage holdings |
| 1913.... | 64.0 | 62.6 | 56.4 | 77.0 | 65.4 | .... | .... | .... | .... |
| 1914.... | 65.5 | 69.2 | 64.9 | 79.0 | 66.0 | .... | .... | .... | .... |
| 1915.... | 70.4 | 77.7 | 76.9 | 79.2 | 67.3 | .... | .... | .... | .... |
| 1916.... | 84.3 | 89.7 | 88.4 | 92.3 | 72.5 | .... | .... | .... | .... |
| 1917.... | 114.3 | 130.0 | 134.3 | 119.6 | 85.6 | .... | .... | .... | .... |
| 1918.... | 127.4 | 132.9 | 132.0 | 134.7 | 97.4 | .... | .... | .... | .... |
| 1919.... | 134.0 | 145.5 | 142.4 | 152.5 | 107.2 | 71.3 | 65.5 | 48.1 | 47.1 |
| 1920.... | 155.9 | 161.6 | 166.5 | 149.9 | 124.2 | 75.0 | 69.9 | 52.6 | 94.2 |
| 1921.... | 110.0 | 102.8 | 100.3 | 108.5 | 109.2 | 66.5 | 60.4 | 65.2 | 86.4 |
| 1922.... | 97.3 | 86.7 | 81.3 | 99.1 | 100.0 | 79.1 | 76.9 | 82.6 | 82.6 |
| 1923.... | 98.0 | 79.8 | 73.3 | 95.1 | 100.0 | 85.5 | 83.8 | 91.4 | 87.8 |
| 1924.... | 99.4 | 87.0 | 82.6 | 97.2 | 98.0 | 84.6 | 82.4 | 102.5 | 114.6 |
| 1925.... | 102.6 | 100.4 | 98.1 | 105.7 | 99.3 | 90.9 | 89.7 | 97.2 | 108.9 |
| 1926.... | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| 1927.... | 97.7 | 102.1 | 99.9 | 105.7 | 98.4 | 106.1 | 105.6 | 103.6 | 110.0 |
| 1928.... | 96.4 | 100.7 | 92.6 | 114.3 | 98.9 | 117.3 | 117.8 | 146.7 | 112.8 |
| 1929.... | 95.6 | 100.8 | 93.8 | 112.5 | 99.9 | 125.5 | 127.4 | 101.1 | 109.6 |
| 1930.... | 86.6 | 82.3 | 70.0 | 102.9 | 99.2 | 109.5 | 108.0 | 103.0 | 128.4 |
| 1931.... | 72.2 | 56.3 | 43.6 | 77.6 | 89.6 | 93.5 | 90.4 | 99.0 | 125.7 |
| 1932.... | 66.7 | 48.4 | 41.1 | 60.7 | 81.4 | 78.7 | 74.0 | 114.3 | 120.1 |
| 1933(7). | 67.2 | 51.0 | 45.7 | 60.9 | 78.0 | 79.2 | 76.8 | 105.1 | 115.4 |
| Jan..... | 63.9 | 43.6 | 35.1 | 57.9 | 79.1 | 68.1 | 62.2 | 56.1 | 112.0 |
| Feb..... | 63.6 | 43.0 | 36.0 | 54.7 | 78.4 | 67.0 | 60.9 | 76.5 | 127.6 |
| Mar..... | 64.4 | 44.7 | 38.0 | 56.0 | 77.8 | 68.4 | 62.5 | 129.0 | 135.8 |
| April... | 65.4 | 46.8 | 41.1 | 56.4 | 78.1 | 69.8 | 65.1 | 104.1 | 112.7 |
| May.... | 66.9 | 51.2 | 46.9 | 58.4 | 77.0 | 76.4 | 72.7 | 95.4 | 100.4 |
| June.... | 67.6 | 52.6 | 49.4 | 57.9 | 77.0 | 82.2 | 79.8 | 221.9 | 119.9 |
| July.... | 70.5 | 60.1 | 60.8 | 59.0 | 77.2 | 84.1 | 82.6 | 136.3 | 114.5 |
| Aug..... | 69.4 | 57.0 | 54.9 | 60.5 | 78.6 | 89.8 | 89.5 | 197.2 | 114.2 |
| Sept.... | 68.9 | 54.7 | 49.5 | 63.4 | 78.8 | 90.8 | 90.2 | 101.1 | 115.7 |
| Oct..... | 67.9 | 51.4 | 44.6 | 62.8 | 77.9 | 88.2 | 87.4 | 70.5 | 112.7 |
| Nov.... | 68.7 | 53.8 | 46.7 | 65.8 | 78.1 | 85.5 | 83.9 | 41.8 | 111.1 |
| Dec..... | 69.0 | 53.3 | 45.3 | 66.6 | 78.4 | 86.2 | 85.1 | 30.7 | 107.6 |
| 1934: | | | | | | | | | |
| Jan. .. | 70.6 | 55.3 | 47.9 | 67.8 | 78.7 | 86.8 | 84.5 | 48.2 | 108.1 |

1. See Prices and Price Indexes 1913-1928, pp. 19-21, 270-289 and 1913-1932, p. 15.

2. Wholesale prices of Canada products of farm origin only. See Prices and Price Indexes 1913-1931, p. 33, and Monthly Mimeographs 1932 and 1933.

3. Wholesale prices of grains, fruits and vegetables.

4. Wholesale prices of Animals and Animal Procudts.

5. Including foods, rents, fuel, clothing and sundries, See Prices and Price Indexes 1913-1928, pp. 181-185, 290-293. 1926 = 100.

Prices and Price Indexes 1913-1931, pp. 122, and Monthly Mimeographs 1932-1933.

6. Monthly Review of Business Statistics, pp. 8, and Monthly Indexes of the Physical volume of business in Canada, supplement to the Monthly Review of Business Statistics, November, 1932.

7. Preliminary.

sown to wheat might advantageously be used in the production of needed and reserve feed supplies." Present low stocks of oats, barley, flax and rye would seem to indicate the desirability of some increase in the acreage of these crops.

*Seeds.*—Increased production of red clover seed is recommended because there is a good demand in both the domestic and foreign markets. Expansion of the acreage of alfalfa warrants increased seed production in favourable areas. The demand for alsike is "critical"; only high grade seed can be moved into the export markets. Sweet clover seed is easily produced in excess of home market requirements and there is little export outlet under present conditions. There is still a deficiency of domestic timothy seed and some increase may be warranted.

*Beef Cattle.*—The trend of beef cattle production is upward, particularly in Western Canada. Prices were very low in 1933. In regard to the proposed restriction of imports into the United Kingdom the report states: "In effect it should also mean more satisfactory prices for Canadian exports. This move indicates very clearly, however, that in the United Kingdom the policy is to place all imports of meats, irrespective of origin on a quota basis..... It is felt that the interests of both countries will be best served by Canada observing the strictest precautions in respect to the selection of stock for export."

*Hogs.*—The hog situation is summarized as follows: "The outlook for hogs appears to be favourable to the producer. It is likely that there will be some temporary price declines during the present year but the trend is upward. Market supply prospects are for a moderate volume during the first half of the year, followed by a fairly substantial increase." Despite the present favourable export outlook improvement in breeding, feeding, selection and pack so as to secure a large percentage of top grades of bacon is much more desirable than an increase in general production. The domestic market should show improvement during the present year.

*Milk Production.*—There was little change in the volume of milk produced in 1933 as compared with that in 1932. The number of milch cows was estimated to have been 3,753,400 in 1933, an increase of 27,900 over the previous year. This increase has been general except in Alberta and British Columbia. The number of dairy heifers has also increased particularly in the Prairie Provinces. Since the milch cow and dairy heifer population is high, production may be expected to be maintained at about the same level as in 1933. This, of course, depends on the extent to which price relationships of agricultural products change.

*Butter.*—Butter production in 1933 was slightly above that for 1932. Imports were higher than during the preceding year but not as high as in 1931. Consumption of butter in Canada was therefore somewhat above that for 1932. Prices at Montreal were also above the level of the previous year.

*Cheese.*—Cheese production was approximately 12,600,000 pounds lower than in 1932. There was a decrease of 2.3% in Ontario and Quebec in which provinces 96.5% of Canadian cheese was produced in 1933. Exports have naturally been lower and domestic consumption was about the same as in 1932. Some emphasis is placed upon the intense competition among exporters of dairy products in the United Kingdom market.

*Apples.*—Increasing production of apples in the province of Quebec, intense competition in the United Kingdom market and curtailment of production of Gravensteins in Nova Scotia, Fameuse in sections of New Brunswick, Quebec and Ontario and Wealthy in Quebec, Ontario and British Columbia are features of the discussion of the apple situation.

*Pears.*—There appear to be good prospects for increased production of Bartlett pears. Experience in recent years has demonstrated that there is a good demand for canned Bartlett's in both domestic and foreign markets.

*Potatoes.*—Farmers usually respond to higher prices by increasing acreage, but a materially increased acreage for the commercial areas in 1934 may have a depressing effect on prices. Plantings should be confined to favoured areas where good seed is available. Consumption seems to have changed but little during the past few years and it may be assumed that an average production from a slightly higher acreage will probably be absorbed in 1934-35 without much change in prices.

*Vegetable Canning Crops.*—Canning requirements in 1934 will likely be normal in most lines with the possible exception of corn. Those favourably situated should consider the possibilities of increasing production of asparagus.

# LA SITUATION ECONOMIQUE

### PREPARE PAR LA DIVISION DE L'ECONOMIE AGRICOLE DU MINISTERE DE L'AGRICULTURE, OTTAWA, ET BASE SUR LES DONNEES RECUEILLIES PAR LE BUREAU FEDERAL DE LA STATISTIQUE

L'analyse habituelle de la situation économique telle qu'indiquée par le tableau des chiffres-indices des prix et du volume de la production, complétée par d'autres données statistiques a été omise dans ce numéro bien que les chiffres-indices pour le mois de janvier aient été ajoutés à ce tableau. Ceci, afin d'attirer l'attention des lecteurs de la Revue Agronomique Canadienne sur le rapport préparé conjointement par les diverses Divisions du Ministère de l'Agriculture, le Service des Renseignements Commerciaux et l'Office Fédéral de la Statistique. Cette première revue de la situation agricole au Canada sera disponible dans la première semaine de mars cette année, mais à l'avenir elle sera publiée un peu plus tôt et les agriculteurs pourront s'en inspirer plus efficacement pour élaborer leur programme agricole de l'année courante. Nous donnons, présentement, un bref résumé de cette revue de la situation agricole, mais pour avoir une vue d'ensemble et juger de l'influence des divers facteurs, il faudrait consulter le rapport complet.

*Demande domestique.* Pour ce qui concerne la demande domestique le rapport dit: "l'amélioration récente de la situation générale des affaires au Canada semble inspirer un regain de confiance dans le marché domestique pour les produits de ferme, mais ces indices ne justifient pas l'attente d'une hausse rapide des prix des produits agricoles; cependant, l'arrêt de la dégringolade des prix presque constante depuis quatre ans et, dans certains cas, une hausse légère des prix durant les derniers mois fournissent des motifs d'encouragement et laissent entrevoir que la demande des produits agricoles canadiens devrait être meilleure prochainement." Parmi ces signes, on peut noter la hausse substantielle qui s'est produite dans l'indice des prix de gros en général et des produits agricoles canadiens, un accroissement régulier du volume de la production industrielle, des conditions meilleures d'emploi et de travail, des faillites commerciales moins nombreuses, des réserves moins fortes de denrées agricoles en entrepôts, et quelques augmentations dans les ventes au détail.

*Demande étrangère.* Dans l'analyse de la demande extérieure ou étrangère, on attribue une certaine importance à ce que 70 pour cent de nos exportations de produits agricoles furent écoulés dans le Royaume-Uni en 1933. L'amélioration récente qui s'est produite dans le situation de l'emploi, une plus grande activité dans les affaires, la reprise de la construction et l'application de programmes de restauration économique laissent entrevoir des améliorations possibles dans le marché anglais pour l'année 1934. Ceci s'applique aussi à la plupart des pays continentaux, quoique le bouleversement de la situation politique constitue un facteur défavorable dans ces cas. Le nationalisme économique qui se traduit en pratique par l'imposition de barrières douanières, les conventions commerciales, les contingentements d'exportation, le contrôle du change, est aussi considéré comme un signe défavorable. Cependant, comme on commence à s'apercevoir que tous ces obstacles au commerce international retarde la reprise des affaires dans tous les pays, il se peut qu'on en atténue graduellement la rigueur mais cela peut-être assez long. En général, la concurrence étrangère continuera d'être vive, bien que le retour à la prospérité mondiale pourra motiver le retrait de certaines mesures de protection établies dans l'intérêt momentané des agriculteurs ainsi que l'atténuation des causes qui intensifient actuellement la concurrence à un degré extrême.

*Grains.* Les prix relativement bas obtenus pour les céréales durant les quatre dernières années n'ont pas causé une réduction substantielle de la superficie totale ensemencée en grains au Canada. Il y a eu cependant un changement sensible dans la production relative des divers grains; les ensemencements d'orge, de seigle, de lin et de sarrasin ont été diminués et on y a substitué le blé, l'avoine et le maïs. "Sauf pour le blé, les stocks de grains seront relativement bas à la fin de juillet. Aussi longtemps qu'il y aura un excédent de blé au Canada, les cultivateurs devraient considérer les possibilités d'utiliser le blé de qualité inférieure comme aliments pour le bétail. Les périodes de sécheresse dans maintes régions durant les dernières années démontrent les avantages qu'il y a de maintenir des réserves de grains d'alimentation et de fourrages sur les fermes. Etant donné qu'il existe actuellement un excédent de blé, une partie du terrain consacré ordinairement aux ensemencements de blé pourrait être utilisé avantageusement pour la production des aliments du bétail requis chaque année ainsi que pour constituer certaines réserves." Les faibles stocks actuels d'avoine d'orge, de lin et de seigle semblent indiquer qu'il serait bon d'augmenter quelque peu les superficies de ces récoltes.

*Semences.* L'augmentation de la production de la graine de trèfle rouge est recommendable, parce que la demande est bonne, tant sur les marchés domestiques qu'étrangers. Une certaine expansion dans l'établissement de luzernuères justifie l'augmentation de la production de la graine de luzerne dans les régions favorables pour cette récolte. La demande pour le trèfle d'alsike est très faible et seule la graine d'alsike de bonne qualité peut être exportée. La graine de trèfle d'odeur est facilement produite en excès des besoins domestiques et, dans les conditions actuelles, il existe peu de débouchés pour l'exportation. La production de la graine de mil au Canada est insuffisante pour les besoins domestiques et la production pourrait en être augmentée raisonnablement.

*Bétail de boucherie.* La production du bétail de boucherie a une tendance à la hausse, particulièrement dans l'Ouest du Canada. Les prix furent très bas en 1933. Comme on a l'intention d'imposer certaines restrictions sur les importations dans le Royaume-Uni, le rapport fait les commentaires suivants: "Ceci signifie que les prix devraient être plus satisfaisants aussi pour les exportations du Canada. Cette mesure indique clairement, cependant, que la politique du Royaume-Uni est d'instituer des contingentements sur toutes les importations de viandes, sans tenir compte du pays d'origine. . .. . "Il semble que ce serait dans le meilleur intérêt des deux pays de faire le choix de notre stock d'exportation avec le plus grand soin."

*Porcs.* La situations de l'industrie porcine est résumée comme suit: "Les perspectives semblent favorables aux éleveurs de porcs. Les prix subiront probablement certaines baisses temporaires durant l'année courante, mais la tendance est à la hausse. D'après ce qu'on peut voir, les envois de porcs sur les marchés seront modérés durant la première moitié de l'année et augmenteront substantiellement par la suite." . . . . En dépit des perspectives actuelles favorables pour l'exportation, l'amélioration des méthodes d'élevage, d'alimentation, de selection et d'emballage, de façon à obtenir un fort pourcentage de bacon d'excellente qualité, est plus recommendable que l'augmentation de la production en général. Le marché domestique devrait s'améliorer au cours de l'année.

*Production laitière.* Il y eut peu de changement dans la quantité de lait produite en 1933 comparativement avec l'année 1932. Le nombre de vaches laitières estimé à 3,753,400 en 1933 montre une augmentation de 27,900 sur l'année précédente. Cette augmentation fut générale, sauf pour l'Alberta et la Colombie Anglaise. Le nombre de génisses laitières a aussi augmenté, principalement dans les provinces de l'Ouest. Comme la population des vaches et des génisses laitières est élevée, la production laitière sera probablement maintenue à peu près au même niveau que durant l'année 1933. Naturellement, ceci dépend dans une certaine mesure des changements relatifs qui se produiront dans les prix des divers produits agricoles.

*Beurre.* La production du beurre en 1933 fut légèrement supérieure à celle de 1932. Les importations furent plus fortes que pour l'année précédente, mais pas aussi considérables qu'en 1931. La consommation du beurre au Canada fut, néanmoins, un peu plus élevée qu'en 1932. Les prix de cette denrée à Montréal furent aussi à un niveau plus élevé que l'année précédente.

*Fromage.* La production du fromage fut envrion de 12,600,000 livres plus faible qu'en 1932. Il y eut une diminution de 2.3 pour cent dans les provinces d'Ontario et de Québec, lesquelles fabriquèrent 96.5 pour cent de la production totale du fromage canadien en 1933. Les exportations furent naturellement plus faibles et la consommation domestique à peu près la même qu'en 1932. On attache assez d'importance à la concurrence intense que se font les exportateurs de produits laitiers sur le Royaume-Uni.

*Pommes.* L'augmentation de la production des pommes dans le Québec, la concurrence active sur le marché du Royaume-Uni, l'opportunité d'une certaine réduction de la production de la pomme Gravensteins en Nouvelle-Ecosse, de la Fameuse dans certaines régions du Nouveau-Brunswick, du Québec et de l'Ontario ainsi que de la Wealthy dans le Québec, l'Ontario et la Colombie sont les principaux points saillants de l'analyse de la situation de la pomiculture.

*Poires.* Il semble y avoir de bonnes perspectives pour une augmentation de la production de la poire Bartlett. L'expérience des denrières années nous a démontré qu'il existe une bonne demande pour les poires Bartlett mises en conserve, tant sur le marché domestique que sur les marchés étrangers.

*Pommes de terre.* Les cultivateurs sont naturellement inclinés à augmenter leurs plantations de pommes de terre quand les prix pour la récolte précédente ont été plus élevés que d'ordinaire, mais une augmentation substantielle des superficies ensemencées en pommes de terre en 1934 dans les régions où l'on fait cette culture principalement pour le commerce pourrait fort bien avoir un effet défavorable sur les prix l'automne prochain. Les plantations devraient donc être limitées en quelques sorte aux régions favorables à cette culture et où l'on peut se procurer de bonnes semences. La consummation de pommes de terre ne semble pas avoir varié beaucoup durant les années passées et l'on peut croire qu'une récolte moyenne, sur une étendue légèrement plus grande, sera probablement absorbée en 1934-35 sans grands changements dans les prix

*Légumes pour la mise en conserve.* Les besoins d'approvisionnement de conserve en 1934 seront probablement à un niveau normal pour la plupart des espèces de légumes, sauf le blé d'Inde. Ceux qui sont situés dans des conditions favorables pourraient peut-être trouver avantageux d'augmenter leur production d'asperges.

## RESUME DES ARTICLES PUBLIES EN ANGLAIS DANS CE NUMERO

La philosophie d'un agriculteur. E. A. Howes, Doyen de la Faculté d'Agriculture, Université de l'Alberta, Edmonton.

Cette causerie fut faite lors du banquet annuel de la C.S.T.A. et des anciens élèves du Collège de Guelph à Toronto en novembre dernier.

L'auteur y fait ressortir le besoin de recherches économiques précises et d'organisation coopératives de vente. Les problèmes de la production eux-mêmes ne sont pas encore résolus. L'auteur avait un jour déclaré à un congrès de la C.S.T.A.: "Si nous pouvons éduquer nos cultivateurs à produire la chose convenable au bon moment et de la façon qu'il faut, nous aurons résolu un des plus gros problèms de la vente." Les nouveaux types de machinerie ne devraient pas être adoptés avant d'avoir été examinés à fond pour voir s'ils sont adaptés aux besoins de la pratique. Une politique agricole à soubresauts est rarement profitable. La causerie se terminait par les mots suivants "La pire chose qu'on puisse léguer aux jeunes est une tendance à se plaindre de leur sort. . . . . Si je pouvais en brandissant quelque bâton magique changer de place avec n'importe lequel de nos jeunes gens d'aujourd'hui, j'échangerois volontiers se jeunesse contre ma position. Je voudrais de nouveau pouvoir être jeune."

LIGNEES SE RAPPORTANT A DES VARIATIONS DE COULEUR DANS LES POMMES DELICIEUSES. C. C. Strachan, Ferme Expérimentale Fédérale, Summerland, B.C.

L'auteur a fait une étude comparative pendant une période de plus de trois années sur des pommes Délicieuses, comparant avec des pommes normales de la variété quatre lignées de pommes rouges qui en sont dérivées par mutation. Les lignées rouges se colorent plus tôt et davantage que les Delicieuses ordinaires. Au moins dans une certaine mesure, cette couleur rouge se développe indépendamment de l'exposition au soleil. Des mesures de la résistance à la pression, du pH, de la conductivité, de la teneur en tanin et en azote, de la respiration et de la perte de poids par évaporation n'ont montré aucune différence significative entre les lignées ordinaires et les lignées rouges. La coloration hâtive des lignées rouges ne s'accompagne pas d'une accumulation hâtive de sucre. En d'autres termes la couleur n'est pas nécessairement associée à la teneur en sucre. Un examen dè fruits rouges et de fruits normaux mûrissant en même temps sur des arbres comparables a montré que tous ces fruits forment leur sucre en même temps et dans les mêmes proportions. Les variations dans l'acidité ne sont pas consistanses. Les qualités de conservation sont les mêmes. Produits dans des conditions uniformes, les fruits des lignées rouges et des lignées normales développent les mêmes quantités de sucre et d'acide pendant l'emmagasinage. Le sucre total augmente jusqu'un certain point pendant que l'acide total diminue graduellement. La couleur de la chair donne une indication satisfaisante de la maturité. Les trois couleurs de la chair communément appelées "verte", "blanche", et "jaune", comparées aux couleurs standard de Ridgway, ont été trouvées similaires, mais non identiques, aux couleurs suivantes:— "Jaune chalcédoine pale", "jaune marguerite" et "jaune de naphthalène". La teneur en sucre des fruits augmente graduellement de la chair verte à la chair jaune. Cette augmentation du sucre total est due principalement à une augmentation du sucrose. Les fruits à chair verte ont donné une qualité inférieure tandis que dans l'ensemble ce sont les spécimens à chair jaune qui one donné la meilleure qualité. Le plus haut pourcentage de fruits à chair verte a été obtenu lors des premiàrs cueillettes et le pourcentage de chair verte a diminué avec les cueillettes successives. Lors de la clasification des Délicieuses ordinaires, presque tous les fruits à chair verte ont été placés dans la classe "C" tandis que dans le cas des variétés rouges certains des fruits à chair verte ont dévéloppé suffisemment de couleur pour être placés dans les classes "fancy" et "extra fancy". Les fruits extra fancy provenant des lignées rouges aussi bien que normales ont été trouvés contenir plus de sucre que les fruits de la classe "C". Les pommes "extra fancy" des lignées rouges ont montré un peu moins de sucre que les pommes de même classe provennant de lignées normales, ce qui probablement est dû à la présence de fruits à chair verte parmi les lignées rouges. Les caractéristiques de croissance des arbres sont similaires dans toutes les lignées mais leur propagation sur un sujet du même groupe révèle une différence quant à leur affinité pour ce sujet.

# NOTES AND NEWS

## PHILOSOPHY FROM AN AGRICULTURIST

In agricultural circles it has become customary to recognize Dean Howes of Edmonton as the "Dean of Deans." He is the senior among the heads of agricultural colleges in Canada, both in age and in years of service. While it may be true that some of our technical agriculturists become swamped with the routine of administrative duties, or the intricacies of scientific investigations, Dean Howes always keeps before us the needs and the aspirations of that sometimes-forgotten man, the farmer.

From time to time he gives us glimpses of the early days. At the Royal Fair last November he combined reminiscences, agricultural economics, and philosophy in an address which is printed in this issue of *Scientific Agriculture.* The manuscript of a book by Dean Howes containing much similar material is in the hands of a Canadian firm which is waiting only for improved business conditions before publishing. In the meantime, those who are able to tune in on the Western network of the Canadian Radio Commission may hear Dean Howes on the evenings of March 8th, 15th, and 22nd.

## BOWLING TOURNAMENT

The second series of the five-pin bowling tournament conducted by C.S.T.A. locals in Ontario and Quebec was rolled during the week of February 12th. Four locals participated with the following results:

1. Average Scores for whole evening:

| | | | |
|---|---|---|---|
| Toronto | 27 players | Average 2 games | 185.3 |
| Montreal | 9 " | " 3 " | 174.4 |
| Ottawa | 24 " | " 3 " | 165.4 |
| Niagara | 10 " | " 4 " | 165.1 |

2. Average Scores on basis of 2 games:

| | | | |
|---|---|---|---|
| Montreal | 9 players | Average for 2 games | 188.2 |
| Niagara | 10 " | " " 2 " | 187.2 |
| Toronto | 27 " | " " 2 " | 185.3 |
| Ottawa | 24 " | " " 2 " | 181.1 |

3. Best Five Players on basis of 2 games:

| | | |
|---|---|---|
| Toronto | (McPhee, Whitelock, McRostie, Hodge, Nixon) | 230.1 |
| Ottawa | (Grindley, Booth, Bentham, Cowan, Chepeswick) | 224.7 |
| Niagara | (Dustan, Palmer, Robb, Upshall, Chamberlain) | 211.0 |
| Montreal | (Asher, Evans, Lanctot, Lefèvre, McGowan) | 205.1 |

4. High individual scores:

| | | | |
|---|---|---|---|
| Toronto | Geo. McPhee | High single game | 304 |
| | " " | High two games | 561 |
| Ottawa | T. W. Grindley | High single game | 281 |
| | " " " | High two games | 531 |
| Niagara | G. G. Dustan | High single game | 298 |
| | " " " | High two games | 530 |
| Montreal | O. R. Evans | High single game | 245 |
| | " " " | High two games | 445 |

Toronto took the lead in three out of four sections of the tournament, with Montreal, Ottawa, and Niagara each having a turn as runner up.

In reporting the results in December, the Niagara scores were omitted. Their inclusion would not have altered the results except that on the evening's average they were three points ahead of Ottawa and would have held third place. In the

December reports the score for high two games for C. H. Hodge should have been 573. This gives Mr. Hodge the record for high two games in the C.S.T.A. tournament, and he also holds the record for high single game at 305.

## AGRICULTURAL OUTLOOK SERVICES

At the last two sessions of the Canadian Society of Agricultural Economics and at the 1932 and 1933 sessions of the National Conference on Agricultural Services resolutions were passed urging the establishment of an agricultural outlook service for Canada. The provinces of Nova Scotia and Saskatchewan are both issuing annually "Farm Outlook" publications as a guide to the planning of production and marketing.

Having in mind the need for a Dominion-wide outlook, the Executive of the National Advisory Committee on Agricultural Services, meeting in Toronto on November 22nd, 1933, appointed an agricultural outlook committee to arrange for an annual study of the agricultural situation. The personnel of this committee is as follows: J. F. Booth, Commissioner, Economics Branch, Department of Agriculture, Ottawa, Chairman; T. W. Grindley, Chief of Agricultural Division, Dominion Bureau of Statistics, Department of Trade and Commerce, Ottawa; J. E. Lattimer, Professor of Agricultural Economics, Macdonald College, Quebec; and J. Coke, Assistant Commissioner, Economics Branch, Department of Agriculture, Ottawa, Secretary. The method of preparing the report is described as follows in the Foreword:

"Early in January of this year an organization meeting was held in Ottawa to consider plans for the undertaking. This meeting was attended by representatives of the Federal Departments of Agriculture and of Trade and Commerce. On that occasion sub-committees were named to assemble the available information and to prepare preliminary reports dealing with various phases of the subject. These reports were later considered and accepted at a general conference held on February 8 and 9, at which time representatives of the Departments of Agriculture of British Columbia, Saskatchewan, Ontario and Quebec were also present.

Since this is the first Canadian report of its kind dealing with the national agricultural situation and outlook, its purpose should be briefly explained. It aims to present in concise form a review of domestic and foreign demand and competition and to analyse the factors affecting the supply of, and the demand for, particular farm products. Issued at a time when farmers are making plans for the ensuing year, or for several years, it is hoped that the report will be of some assistance. In this respect it is intended to supplement and to co-ordinate, rather than to displace, reports dealing with current information that are issued periodically by different departments.

While the facts disclosed by this survey of our basic industry give ground for some optimism concerning the future, the forecasting of economic recovery and of the trend of prices has not been considered the primary purpose of this work. On the contrary, it should be considered as an effort to present basic information and, within certain limits, to offer such interpretations as may be helpful to those engaged in farming.

The committee is desirous that full credit for the preparation of the various sections comprising this completed report be given to the officials who co-operated in their preparation, and that special recognition be given Messrs. T. G. Major, A. E. Richards, and P. E. Light for assistance in arranging and editing the manuscript."

The report of the committee is published under the title of *The Agricultural Situation*, and is issued by the joint authority of the Hon. Robert Weir, Minister of Agriculture, and the Hon. H. H. Stevens, Minister of Trade and Commerce. Copies are available on request from the Publications Branch, Department of Agriculture, Ottawa. A brief resumé of the report is given in *The Economic Situation* in this issue of *Scientific Agriculture*. The preparation of this outlook has entailed a considerable amount of hard work, and the representatives of the several Federal and Provincial Departments are to be congratulated on making their report available at this date. In succeeding years it will be possible to develop a more extensive organization which will make it possible to publish the outlook at the opening of the year.

## CANADIAN BACON NOW GRADED FOR EXPORT

The problem of the quality of Wiltshire sides exported to Great Britain has been before the Dominion Department of Agriculture for many years. With many exporters all grading according to their own interpretation of what the British market would absorb, and with the inability of any one exporter to guarantee a steady supply of any grade which might find favour in certain markets, the difficulties of building up a steady trade are obvious.

At the Imperial Economic Conference in Ottawa in 1932 Canada was allotted a quota in the British market which allowed for an enormous expansion in our trade in bacon. The opportunity carried with it the danger of a possible lowering of quality on the part of producers and exporters to meet the demands for quantity.

The whole problem was reviewed very carefully by Federal and Provincial officials and exporters at the National Conference on Agricultural Services held in Toronto in August 1932 immediately following the Imperial Economic Conference. At the Toronto meeting a resolution was passed requesting the Federal Minister of Agriculture to take such steps as were necessary to protect the quality of our export bacon, and to popularize Canadian bacon on the British markets. It was intimated by the packing interests that they were ready to join the government in developing some suitable system of supervision of exports if this were deemed advisable. At the second National Conference on Agricultural Services held in Regina in July 1933 it was reported by the bacon committee that regulations for the grading of export bacon had been prepared and would become effective as soon as passed by an Order-in-Council. It has recently been announced that such a order was passed on the 16th of September 1933, and that the regulations went into effect on March 5, 1934. The following statement respecting the operations of the system has been issued by the Federal Department.

" Under these regulations the right to export Wiltshire sides of bacon directly or indirectly to the United Kingdom is by licence issued by the Minister of Agriculture upon application in writing. The applicant must satisfy the Minister that he can produce the bacon required by the provisions of the regulations, and all such bacon and the containers must be stamped, stencilled, or branded in a neat and clear manner with such data as may be required from time to time.

Each shipment of bacon is accompanied by a statement signed by the exporter showing the selections and grades and the number of packages. The statement also bears the signature of the inspector of the Health of Animals Branch, Dominion Department of Agriculture, who checked and supervised the shipment. The onus of grading properly will thus be on the exporter, and in the event of breach of any of the regulations the Minister of Agriculture may suspend or cancel the exporter's licence. There are three grades, A, B, and C.

By these regulations it is hoped that the principle of grading which has produced such fine results in building up Canada's export trade in fruit, dairy, and other agricultural products, will effect a similar advance in the Dominion's bacon trade. Although Canada's share of the British market increased in 1933 to 506,000 cwts. from 181,000 cwts. in 1932 and 49,000 cwts. in 1931, Canada's shipments represent only 5% of the British bacon imports from all sources, and it is to be remembered that Great Britain spends on an average $5,000,000 every day in imported food."

## W. H. SPROULE HEADS O.A.C. DAIRY DEPARTMENT

Announcement has recently been made that Professor W. H. Sproule has been appointed Head of the Dairy Department at the Ontario Agricultural College. He has been acting in this position since the retirement of Professor H. H. Dean in September 1932, and has been with the Dairy Department since graduation in 1920. Professor Sproule is a native of Vankleek Hill in Eastern Ontario and during his college course served in the Canadian army and later became Assistant Agricultural Representative for Lambton County.

Professor Sproule has specialized in butter making and has done a considerable amount of experimental work of value to the creamery men throughout the province. Appreciating the value of the co-operation of all agencies interested in experimental work in dairying, he helped to organize two years ago the Ontario Dairy Research Council, on which there is representation from commercial organizations, the Federal Department of Agriculture, the Ontario Agricultural College, and others interested. Under his direction the Dairy Department will undoubtedly continue its development, becoming of even greater service to the dairying interests of the province.

## NEWS ITEMS

A. T. Elders (Manitoba '24), formerly Assistant Professor of Agronomy, Manitoba Agricultural College, Winnipeg, Man., has been appointed Experimental Farm Assistant at the Dominion Experimental Farm, Brandon, Man.

W. S. Van Every (Toronto '22), has changed his address to 15 Trafalgar Street, St. Catharines, Ont.

C. A. Lamb (British Columbia '21), who has been taking post-graduate work at Cornell, has returned to his work at the Ohio Agricultural Experiment Station, Wooster, Ohio.

C. Shirriff (Manitoba '29), has changed his address to Box 50, Swift Current, Sask.

The General Secretary desires to express his sincere appreciation of the very substantial expression of good-will recently received from the officers and members of the C.S.T.A. locals throughout the Dominion. The fund raised relieves to a considerable extent the personal burden which was still being carried as a result of the unfortunate accident which occurred on the way to the Guelph convention. The carrying of this burden in addition to the added responsibilities arising out of the World's Grain Exhibition and Conference and the difficulties of financing the Society under present conditions have made the situation almost intolerable at times. The thoughtfulness and generosity of the Executive and members of the C.S.T.A. has given the General Secretary new courage. With some rearrangements which are taking place in the financing of *Scientific Agriculture*, and with the general improvement in business conditions, prospects for the Society now look brighter than at any time during the past two years.

SCIENTIFIC AGRICULTURE

Vol. XIV APRIL, 1934 No. 8

# NUTRITIONAL STUDIES WITH FRAGARIA II[1]

## A STUDY OF THE EFFECT OF DEFICIENT AND EXCESS POTASSIUM, PHOSPHORUS, MAGNESIUM, CALCIUM, AND SULPHUR

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[Received for publication October 10, 1933]

In Pamphlet No. 96 of the Dominion Department of Agriculture we reported on the effects of nitrogen, potassium, and phosphorous starvation in strawberry plants. It was shown that certain rather definite symptoms were exhibited by the plant in the absence of any one of these elements. Later, in the 1928 Report of this Division, we reported on a more complete series of experiments in which strawberry plants were subjected to certain periods of starvation for the elements referred to above. In this last report we were able to corroborate some of the points brought out in the earlier publication, particularly as regards foliage tints developed and the effect of phosphorus and potassium on set.

In this report we propose to deal more fully with the effects of the deficiency of the above elements, and, in addition, to discuss the effects of deficient magnesium, calcium, and sulphur, and the results obtained from an addition of an excess of any of the elements above mentioned.

## MATERIALS AND METHODS

### METHODS EMPLOYED

One variety of strawberry was employed, namely, Parson Beauty. The plants were grown in the field from the time the young stolons rooted until the following spring, when they were lifted, graded as to size, and transplanted to six-inch pots. The medium used in the pots consisted of finely ground sandstone from the same quarry as reported in (*1*).

The experiment has been conducted with three separate batches of material in three separate years and the results reported below are based on observations spread over that time. In the case of foliage and growth characteristics we are able to present data from three seasons, whereas in the event of yield, data from two seasons only are presented, owing to losses by winter injury in 1929.

### NUTRIENT TREATMENTS

Forty-six different treatments were given which may be divided into five main groups, viz.: the potassium group, the phosphorus group, the magnesium group, the calcium group, and the sulphur group. Each of these groups was divided into an excess section and a deficiency section. In the excess section there were four different series, each series receiving an increment of the element in question over that given to the previous series.

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[1] Contribution from the Laboratory of Plant Physiology, Horticultural Division.
[2] Dominion Horticulturist.
[3] Assistant in Horticultural Research.
[4] Assistant Chemist, Chemistry Division.

TABLE 1.—PARTS PER MILLION OF ELEMENTS

| Series | Mg | K | Ca | N | S | P | Cl | Total |
|---|---|---|---|---|---|---|---|---|
| 1 | 14.1 | 49.7 | 97.3 | 240.9 | 18.6 | 26.1 | 187.3 | 634 |
| 2 | 14.1 | 99.4 | 97.3 | 240.9 | 18.6 | 26.1 | 187.3 | 683.7 |
| 3 | 14.1 | 149.0 | 97.3 | 240.9 | 18.6 | 26.1 | 187.3 | 733.3 |
| 4 | 14.1 | 198.8 | 97.3 | 241.3 | 18.6 | 26.1 | 187.3 | 783.5 |
| 5 | 14.1 | 248.5 | 97.3 | 241.1 | 18.6 | 26.1 | 187.3 | 833.0 |
| 6 | 14.1 | | 97.3 | 240.9 | 18.6 | 26.1 | 172.1 | 569.1 |
| 7 | 28.2 | | 194.6 | 481.8 | 37.3 | 52.0 | 324.2 | 1118.1 |
| 8 | 42.3 | | 291.9 | 722.7 | 55.9 | 78.3 | 516.3 | 1707.4 |
| 9 | 56.4 | | 389.2 | 963.6 | 74.4 | 104.0 | 688.4 | 2276.0 |
| 10 | 84.6 | | 583.8 | 1445.4 | 111.6 | 156.0 | 1032.6 | 3414.0 |
| 11 | 14.1 | 49.7 | 97.3 | 240.9 | 18.6 | 52.0 | 187.3 | 659.9 |
| 12 | 14.1 | 49.7 | 97.3 | 240.9 | 18.6 | 78.0 | 187.3 | 685.9 |
| 13 | 14.1 | 49.7 | 97.3 | 240.9 | 18.6 | 104.0 | 187.3 | 711.9 |
| 14 | 14.1 | 49.7 | 97.3 | 240.9 | 18.6 | 130.0 | 187.3 | 737.9 |
| 15 | 14.1 | 49.7 | 97.3 | 240.9 | 18.6 | | 187.3 | 607.9 |
| 16 | 28.2 | 99.4 | 194.7 | 481.8 | 37.2 | | 374.5 | 1215.8 |
| 17 | 42.3 | 149.0 | 292.0 | 722.7 | 55.9 | | 561.8 | 1823.7 |
| 18 | 56.4 | 198.6 | 389.3 | 963.6 | 74.5 | | 749.1 | 2431.5 |
| 19 | 84.7 | 297.9 | 584.0 | 1445.4 | 111.7 | | 1123.7 | 3647.4 |
| 20 | 28.2 | 49.7 | 97.3 | 240.9 | 18.6 | 26.1 | 187.3 | 648.1 |
| 21 | 42.3 | 49.7 | 97.3 | 241.0 | 18.6 | 26.1 | 187.3 | 662.3 |
| 22 | 56.4 | 49.7 | 97.3 | 241.0 | 18.6 | 26.1 | 187.3 | 676.4 |
| 23 | 70.5 | 49.7 | 97.3 | 241.8 | 18.6 | 26.1 | 187.3 | 691.3 |
| 24 | | 49.7 | 97.3 | 240.9 | 18.6 | 26.1 | 146.2 | 578.8 |
| 25 | | 99.4 | 194.6 | 481.8 | 37.2 | 52.2 | 292.0 | 1157.2 |
| 26 | | 149.2 | 291.9 | 722.7 | 55.8 | 78.2 | 438.0 | 1735.8 |
| 27 | | 199.8 | 389.2 | 963.6 | 74.4 | 104.3 | 584.0 | 2315.3 |
| 28 | | 297.9 | 583.8 | 1445.4 | 114.5 | 156.5 | 877.2 | 3475.3 |
| 29 | 14.1 | 49.7 | 194.7 | 240.9 | 18.6 | 26.1 | 359.5 | 903.6 |
| 30 | 14.1 | 49.7 | 292.0 | 240.9 | 18.6 | 26.1 | 531.4 | 1172.8 |
| 31 | 14.1 | 49.7 | 389.3 | 240.9 | 18.6 | 26.1 | 703.5 | 1442.2 |
| 32 | 14.1 | 49.7 | 486.7 | 240.9 | 18.6 | 26.1 | 875.5 | 1711.6 |
| 33 | 14.1 | 49.7 | | 240.9 | 18.6 | 26.1 | 15.2 | 364.6 |
| 34 | 28.2 | 99.4 | | 481.8 | 37.2 | 52.2 | 30.4 | 729.2 |
| 35 | 42.3 | 149.2 | | 722.7 | 55.9 | 78.2 | 45.6 | 1093.9 |
| 36 | 56.4 | 198.8 | | 963.6 | 74.5 | 104.3 | 60.8 | 1458.4 |
| 37 | 84.7 | 298.3 | | 1445.4 | 111.7 | 156.5 | 91.3 | 2187.9 |
| 38 | 14.1 | 49.7 | 97.7 | 240.9 | 37.7 | 26.1 | 145.6 | 611.8 |
| 39 | 14.1 | 49.7 | 97.7 | 240.9 | 57.8 | 26.1 | 103.4 | 589.7 |
| 40 | 14.1 | 49.7 | 97.7 | 240.9 | 75.9 | 26.1 | 61.2 | 565.6 |
| 41 | 14.1 | 49.7 | 97.7 | 240.9 | 94.9 | 26.1 | 19.1 | 542.5 |
| 42 | 14.1 | 49.7 | 97.7 | 240.9 | | 26.1 | 187.3 | 615.8 |
| 43 | 28.2 | 99.4 | 194.7 | 481.8 | | 52.2 | 374.5 | 1230.8 |
| 44 | 42.3 | 149.2 | 292.0 | 722.7 | | 78.2 | 561.8 | 1846.2 |
| 45 | 56.4 | 198.8 | 389.3 | 963.6 | | 104.3 | 749.1 | 2461.5 |
| 46 | 84.6 | 298.3 | 584.0 | 1445.4 | | 156.5 | 1123.7 | 3692.5 |

Thus, in the excess potassium section the first series received twice the amount of potassium applied to the check. The second series received three times that given to the check, increasing to five times that given in the check or normal series. This same system was followed in each of the other excess sections.

In the deficiency sections the first series received all elements in normal application excepting the element in deficiency which was completely omitted. The second series received all elements at twice the normal concentration as the check, increasing in further series until the elements fed were given at six times the normal concentration with the deficient element entirely absent.

In 1929 and 1930 the parts per million fed to each series were as in Table 1, whereas in 1931 the p.p.m. were altered by tripling the amount of potassium in the normal or check solution; all other elements fed remained the same as in Table 1.

### METHODS

(1) *Cultural.*—The pots employed were 6-inch ordinary clay pots. The treatments were all given out of doors and no attempt was made to prevent rain from getting access to the pots. The pots were all set out in a cold frame, each pot having a clay saucer under it. Several inches of space surrounded each pot and a foot or more was left between each series. To enable the moisture and root temperature to be more easily controlled, well washed river sand was placed between each pot.

(2) *Feeding.*—Feeding was not started until the plants had become established in the pots. The first feeding was given in late May at which time 200 cc. of the dilute solutions was fed to each pot. Thereafter feeding was conducted once a week at the same rate. Watering was carried out when necessary, the plants being watched carefully and an attempt being made to maintain uniform and optimum moisture conditions throughout. At no time in the experiment did the water supply become a limiting factor.

*Nutrient Solutions.*—The nutrients employed were Baker's C.P.; these were made into stock solutions and measured amounts, according to requirements, were used. The stock solutions were as follows:—

$MgSO_47H_2O$—110 g. in 2000 cc. (1 cc. contains 55 mg.)
$KH_2PO_4$—85 g. in 1700 cc. (1 cc. contains 50 mg.)
$KCl$—25 g. in 1000 cc. (1 cc. contains 25 mg.)
$CaCl_2$—240 g. in 4000 cc. (1 cc. contains 60 mg.)
$NHNO_3$—350 g. in 3500 cc. (1 cc. contains 100 mg.)
$KNO_3$—30 g. in 1000 cc. (1 cc. contains 30 mg.)
$MgNO_36H_2O$—35 g. in 1050 cc. (1 cc. contains 30 mg.)
$NH_4H_2PO_4$—30 g. in 1000 cc. (1 cc. contains 30 mg.)

The details of the solution for Series 1 will exemplify the method employed throughout.

Amount of stock solution in 5000 cc. water:—

| | | | |
|---|---|---|---|
| $MgSO_47H_2O$ | 13 + cc. | $CaCl_2$ | 23 cc. |
| $KH_2PO_4$ | 12 “ | $NH_4NO_3$ | 34 “ |
| $KCl$ | 6 + “ | | |

The details of the solution below will illustrate how the solution was prepared in the event of the complete withdrawal of an element, in this case potassium.

| | | | |
|---|---|---|---|
| $MgSO_47H_2O$ | 13 + cc. | $NH_4NO_3$ | 33 cc. |
| $CaCl_2$ | 23 “ | $NH_4H_2PO_4$ | 16 “ |

## RESULTS

### FOLIAGE AND GROWTH OBSERVATIONS

The notes which were taken on foliage and growth characteristics revealed certain symptoms which could be associated with the treatment given in the majority of cases. These will be presented under the group headings.

The complete nutrient group, represented by Series 1, displayed good vigour and good foliage colour throughout the summer of 1929 and did not reveal any very marked symptoms of a deficiency nature. In the 1930 experiment this series, although exhibiting good growth, showed in late August, 1930, some purpling of the older leaves and a slight tendency for some of the leaves to curl upwards. As this appeared less pronounced in series 2 and 3, it was considered that the normal solution was possibly a little low in potassium or phosphorus.

Group 2 (excess potassium) represented by Series 2, 3, 4 and 5, behaved much as Series 1, although Series 4 and 5 did show slightly darker foliage and gave a slightly more vigorous appearance. All series looked as if they were slightly deficient for either potassium or phosphorus, the foliage tints resembling to a certain degree those exhibited by both the low potassium and the low phosphorus groups. As will be noted later, the low calcium, low magnesium, and low sulphur groups had none of these purplish or reddish-purple tints, so that it was suspected that probably the plants were not able to get hold of sufficient potassium or phosphorus, although ample was being supplied in the rations. This point will be discussed later.

Group 3 (potash deficient) represented by Series 6, 7, 8, 9 and 10, showed marked symptoms as early as July 2, when the leaves of Series 6 were abnormally dull and dark in colour, lacking the lustre of a normal leaf. Series 7 to 10 inclusive, showed drooping foliage at this date, with the leaves curling upwards and inward and Series 10 much reduced in vigour and the leaf petioles decumbent. This condition became aggravated in all series of this group and by August 12th very definite wilting was noticeable in all series, increasing in intensity from Series 6 to 10. This was accompanied by a distinct purpling on the underside of the majority of the leaves. In Series 7–10 a mosaic-like mottling was observed on many leaves and a large number of newer leaves in all series of this group, showed a burning of the margins, which by early September had become very pronounced, resulting in the death of many leaves.

Group 4 (excess phosphorus) including Series 11 to 14:—By late June, while Series 11 and 12 displayed normal colour and vigour, Series 13 and 14 began to display some slight burning of the foliage and a slight reduction in vigour. By September the older leaves in all series were light red in colour and only Series 11 continued to display normal vigour and colour of younger leaves, the burning of the margin of leaves in all other series being marked.

Group 5 (phosphorus deficient) including Series 15 to 19:—All series in this group began to display poor vigour and very dull brownish-green foliage in early June. The older leaves turned to a bronzed red, leaves became reduced in size and bronzing of all leaves became noticeable. Many plants were dead by early August.

Group 6 (excess magnesium) containing Series 20 to 23:—All series in this group resembled the normal very much in vigour, but as the season advanced very slight signs of marginal scorch developed. One or two plants exhibited a slightly chlorotic condition which, as in all the others, was soon followed by scorch. By September the older leaves showed considerable purpling indicating, as in the normal, a lack of either potassium or phosphorus. This was a more outstanding symptom than the slight amount of scorch present.

Group 7 (magnesium deficient) containing Series 24 to 28:—As a group these series were for a long time each season, previous to the fruiting year, among the most vigorous looking plants. They displayed large leaves, with no trace of tints or scorch until late August, when characteristic patches of brown, mostly confined to the margins, developed. These brown blotches or patches frequently fell out, leaving a gap in the margin. The petioles were always longer than in the normal series.

Group 8 (excess calcium) containing Series 29 to 32:—This entire group displayed lack of vigour and dark, dull green foliage, followed by purpling of older leaves and a great deal of scorch and blotch. The leaves were smaller and more sessile, with shorter petioles. In many respects they resembled the low potassium series and also the low phosphorus series. In the higher numbered series distinct curling inwards and upwards was noticeable, with the underside reddish-purple.

Group 9 (deficient calcium) containing Series 33 to 37:—These series exhibited exceptional vigour, with large leaves, long petioles and no tints. It was not until early fall of each season that a certain amount of blotch, similar to that described under the magnesium deficient series, developed. From that date onward leaves appeared restricted in growth extension.

Group 10 (excess sulphur) containing Series 38 to 42:—This group displayed normal growth vigour and colour until mid-summer, at which time the older leaves began to exhibit marked reddish purpling of older leaves, this being more pronounced in the higher numbered series of the group; size of leaves somewhat reduced, with shortened petioles. All these series exhibited in varying degree a certain amount of phosphorus deficiency.

Group 11 (sulphur deficient) including Series 42 to 46:—This group in 1929 continued to display excellent vigour and colour throughout, being one of the most vigorous groups in the experiment, without any definite foliage tints. In 1930-31, while as a group the larger leaf and longer petiole, expressive of excellent vigour, was noticeable, they did exhibit, particularly in the higher numbered series, a slight amount of apex blistering, which did not appear until late summer. In Series 46 this became quite general by mid-September. While this was not noted in 1929, it may have been passed up, as it was the appearance of an entirely new symptom which could easily have been unobserved.

Since this apex blistering was present more in the higher series, that is in those series having all elements in greater concentration, it is doubtless associated with high nitrogen in the absence of sulphur. A very small amount of apex blistering has been noticed wherever a sufficient excess of nitrogen has been fed, but it was more severe in the absence of sulphur than in the absence of any other element. In the higher deficient potassium series this was not noticeable as apex blistering, but took the form of more aggravated leaf scorch.

## WINTER HARDINESS, 1929

In the fall the potted plants were covered over with a mulch of straw, similar to that given plants in the field. As very few plants came through the winter alive the yield data are of little significance and are not reported for this year.

The winter injury data, however, offer one or two outstanding points of interest. All series in which potash, sulphur, magnesium or phosphorus was deficient killed almost 100%, the minus calcium series were less affected, and the excess sulphur series showed less injury than any, with the excess potassium series coming second.

The results on this point from the 1930 experiment are given in a little more detail in Table 2.

TABLE 2.—WINTER INJURY IN DIFFERENT GROUPS OF THE 1930 EXPERIMENT. NOTES TAKEN IN SPRING, 1931

| Series | Percentage of plants killed | |
|---|---|---|
| 1 | 0 | Excess potassium group. |
| 2 | 16 | |
| 3 | 9 | |
| 4 | 7 | |
| 5 | 40 | |
| 6 | 33 | Deficient potassium group. |
| 7 | 93 | |
| 8 | 100 | |
| 9 | 100 | |
| 10 | 100 | |
| 11 | 25 | Excess phosphorus group. |
| 12 | 40 | |
| 13 | 9 | |
| 14 | 70 | |
| 15 | 16 | Deficient phosphorus group. |
| 16 | 45 | |
| 17 | 75 | |
| 18 | 63 | |
| 19 used for analysis | | |
| 20 | 9 | Excess magnesium group. |
| 21 | 14 | |
| 22 | 20 | |
| 23 | 9 | |
| 24 | 30 | Deficient magnesium group. |
| 25 | 63 | |
| 26 | 100 | |
| 27 | 100 | |
| 28 | 100 | |
| 29 | 4 | Excess calcium group. |
| 30 | 6 | |
| 31 | 25 | |
| 32 | 12 | |
| 33 | 30 | Deficient calcium group. |
| 34 | 30 | |
| 35 | 33 | |
| 36 | 50 | |
| 37 | 100 | |
| 38 | 55 | Excess sulphur group. |
| 39 | 18 | |
| 40 | 33 | |
| 41 | 11 | |
| 42 | 33 | Deficient sulphur group. |
| 43 | 18 | |
| 44 | 36 | |
| 45 | 85 | |
| 46 | 75 | |

Aside from Series 1, the complete nutrient series, the amount of injury was quite marked, deficient potassium and deficient magnesium producing the most marked results. The excess sulphur group again showed a tendency toward less winter injury, along with excess calcium and excess potassium. As will be noted in some groups, as for instance the excess potassium and excess phosphorus groups, the figures are not consistent, whereas in the deficient potassium, deficient magnesium and deficient calcium groups, the injury increased very consistently with the increase in concentrations of the other elements. On the other hand, in the excess sulphur group the injury consistently decreased with the increments of sulphur. This is probably the only information of any possible value in these results, as it would be expected that large amounts of injury would result from the deficient potassium and magnesium groups, although the latter plants really entered the winter in apparently a fair condition, certainly much better than the low phosphorus plants which came through with less injury. The possibility of sulphur influencing the winter hardiness of strawberry plants will be further examined. In the meantime it can only be accepted as a possible function of sulphur.

## YIELD DATA

It is not possible in a report of this length to present the tabulated yield data. It may be said that each pot was treated as a separate plot. The number of blossoms produced by each plant was recorded as well as the number of fruits actually matured. No attempt was made to weigh the crop as each weighing from individual plants would be subject to a great deal of error on account of the small number of fruits produced at each picking. The data have been handled statistically and analysis of variance made. The following remarks are based only on such statistical analysis, only significant differences being taken into consideration.

In the case of the number of blossoms produced there has not been any significant decrease in blossom production, due to excess potassium, until the parts per million of potassium fed were in excess of 248, after which there was a significant reduction in the number of blossoms formed. In 1929 and 1930 the withdrawal of potassium brought about an almost significant reduction in bloom, while in 1932 the reduction was greater than that due to the greatest excess of that element. In the presence of higher nitrogen the absence of potassium in 1932 reduced the yield to almost a negligible quantity, whilst in 1929 and 1930 it resulted in the death of most of the plants.

*Excess Phosphorus Group.*—There appears to be a very close relationship between phosphorus and potassium in influencing fruit bud formation. High phosphorus feeding in the presence of high potassium feeding appears to bring about increased yield but high phosphorus feeding in the presence of low potassium brings about reduced yield. This point is made clearer by reference to Figure 1. It will be noted that the curve drops rather sharply as the ratio of potassium to phosphorus increases. Since the yield curve is inverse to the curve presented here, the effect of the potassium phosphorus relationship in influencing yield, is quite apparent. It would seem that the relationship should be in the vicinity of 3 to 1; that is to say,

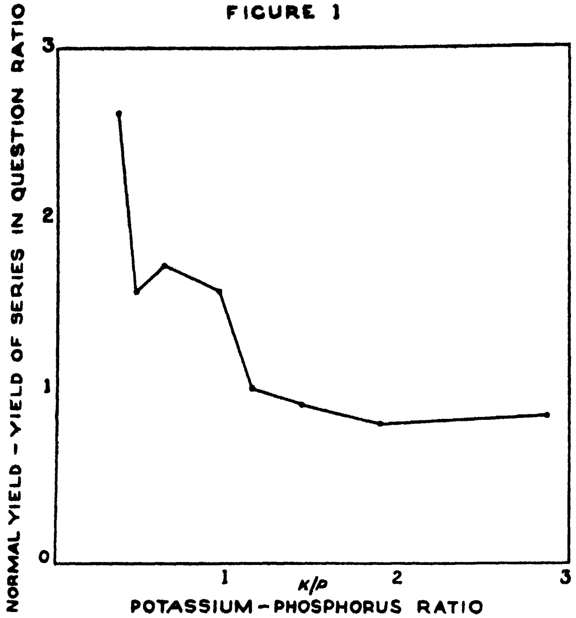


FIGURE 1. The effect of the Potassium-Phosphorus ratio in the nutrient solution in influencing yield.

the amount of potassium fed to the strawberry plant should be three times the amount of phosphorus to obtain maximum fruit bud formation.

In all experiments the withdrawal of phosphorus has caused a very marked reduction in fruit bud formation, much greater than the withdrawal of potassium. As in the case of the low potassium series, the reduction was greater in the presence of high nitrogen than in the presence of low nitrogen.

When excess magnesium was fed, significant differences were produced which would indicate the amount of magnesium fed should be from 1/3 to 1/4 the amount of potassium fed. Where the amount of magnesium fed was increased beyond 1/3 that of the potassium fed, a marked reduction in yield took place.

The complete withdrawal of magnesium did not have as much effect on fruit bud formation as did the withdrawal of phosphorus or potassium, although a significant reduction took place. Unlike the minus phosphorus or potassium groups this reduction was not further increased by the presence of higher nitrogen.

The effect of excess calcium feeding on fruit bud formation was very marked when the amount of calcium fed was greater than three parts of calcium to one part of potassium fed. The withdrawal of calcium did not produce a significant effect on fruit bud formation until very large quantities of nitrogen were fed.

The excess feeding of sulphur did not significantly reduce the number of buds formed until 94 parts per million of sulphur were fed as in Series 41, when a significant reduction took place. The withdrawal of sulphur in the presence of a normal application of nitrogen did not bring about any reduction of yield but the complete withdrawal of sulphur in the presence of higher nitrogen brought about a very marked reduction in yield. There appears to be a very definite connection between sulphur and nitrogen which will bear further investigation.

In considering these data it must be remembered that where an element is said to be fed in excess we do not actually know that it was in excess; the term is but arbitrary. Whether or not it is in excess must be judged by the results obtained.

It would appear from a careful examination of blossoms, which indicates the number of fruit buds formed, that excess phosphorus feeding would probably be the most likely cause of trouble unless the available potassium was very high. The next most important point would likely be the high feeding of calcium and here again it appears to be a relationship with potassium. While it appears possible to reduce yield by excessive magnesium feeding, it is only when the concentration of that element has been raised to four times the normal that a significant reduction takes place.

In studying the effect of deficiency we should only deal with the first series of each group, for in the others the results may be due to toxicity of nitrogen or even of some other element. On this basis it is surprising that the potassium originally stored in the plant during its early days, has been able to maintain fruit bud production at such a high level, whilst the mere withdrawal of phosphorus has very markedly reduced fruit bud formation. It would appear that in so far as the actual formation of fruit buds is concerned there is little danger of over-feeding with potassium, magnesium or sulphur, but that excessive feeding of phosphorus or calcium is by no means a remote possibility in reducing the formation of fruit buds.

On the other hand there appears a marked ability on the part of the strawberry plant to utilize a small amount of stored potassium, so that if the plant is grown for a season under normal conditions and then subjected to low potassium conditions, the plant is able to cope with the situation to an almost efficient degree. This situation does not exist, however, with regard to deficient phosphorus or magnesium, which are soon reflected in reduced fruit bud formation, so that the danger of under-feeding of phosphorus or magnesium is of real importance. Low feeding of calcium or sulphur is not liable to be attended with any marked decrease in fruit bud formation.

## CHEMICAL-CARBOHYDRATE ANALYSIS

Table 3 gives the result of analyses of the tops of certain series in terms of reducing sugars, sucrose, polysaccharides (as starch) and total nitrogen. The material for analysis was gathered in late October, the year previous to fruiting. Whilst there was considerable variation between some of the series, there are one or two points of outstanding significance. Thus, in the fact that the withdrawal of potassium resulted in a marked reduction in total carbohydrates. As the concentration of the other elements increased, or, in other words, as the ratio of potassium to other elements became wider, this reduction was more pronounced. This reduction appeared in reducing sugars, sucrose, and starch until only a trace of starch was found in Series 9. The addition of extra phosphorus has brought about a marked reduction in carbohydrates also, but just why Series 14 should show an increase over Series 11 is unexplainable at this stage, unless the slight difference existing is due entirely to error in sampling.

Deficient phosphorus has reduced carbohydrates about the same as deficient potassium and, as in deficient potassium, the decrease is more pronounced as the ratio of phosphorus to other elements becomes wider. It is also interesting to note that only a trace of starch was found in Series 18, as in Series 9, while the sucrose figure remained the same and did not, as in the comparable deficient potassium series, decrease.

TABLE 3.—ANALYSIS OF FOLIAGE (STEMS AND LEAVES)—MATERIAL GATHERED OCTOBER 14, 1930

| Green weight | Dry weight | Percent dry weight | Dry matter basis | | | | | Nutrient solution | Series |
|---|---|---|---|---|---|---|---|---|---|
| | | | Reducing sugars | Sucrose | Poly-saccharides (as starch) | Total carbo-hydrates | Total nitrogen | | |
| gms. | gms. | p.c. | p.c. | p.c. | p.c. | p.c. | p.c. | | |
| 60.27 | 22.54 | 37.4 | 3.67 | 4.97 | 8.77 | 17.41 | 1.70 | Complete | 1 |
| 75.95 | 25.44 | 33.5 | 3 09 | 5.72 | 10 44 | 19.25 | 1.80 | +2K | 2 |
| 65.97 | 24.52 | 37.3 | 2.77 | 6 57 | 8.03 | 17.37 | 1.63 | +4K | 5 |
| 50.75 | 18.78 | 37.0 | 1.13 | 3.66 | 0.99 | 5.78 | 2.48 | −K | 6 |
| 29.74 | 9.64 | 32.4 | 0.35 | 1.97 | trace | 2.32 | 4.83 | −K × 4 | 9 |
| 38.45 | 14.63 | 38.1 | 2.97 | 3.54 | 1.04 | 7.55 | 2.43 | +P | 11 |
| 42.0 | 15.14 | 36.1 | 1 91 | 5.53 | 1.42 | 8.86 | 2.67 | +4P | 14 |
| 33.0 | 13.53 | 41.0 | 2.51 | 0.96 | 2.08 | 5 55 | 2.00 | −P | 15 |
| 28.0 | 12.11 | 43.2 | 1.93 | 0.99 | trace | 2.92 | 2.64 | −P × 4 | 18 |
| 49.0 | 17.89 | 36.5 | 2.18 | 4.94 | 0.44 | 7.56 | 1.98 | +Mg | 20 |
| 49.0 | 17.68 | 36.1 | 2.36 | 5.20 | none | 7.56 | 1.85 | +4Mg | 23 |
| 49.0 | 19.93 | 41.7 | 0.57 | 3.17 | none | 3.74 | 1.76 | −Mg | 24 |
| 40.0 | 13.97 | 34.9 | trace | 1.49 | none | 1.49 | 3.62 | −Mg × 4 | 27 |
| 40.0 | 14.50 | 36 2 | trace | 0.59 | 0.88 | 1 47 | 2.22 | +Ca | 29 |
| 40.0 | 14.87 | 37.2 | 0.27 | 0.43 | none | 0.70 | 2.43 | +4Ca | 32 |
| 40.0 | 15.08 | 37.7 | 0 13 | 1.07 | 0.35 | 1.55 | 2.02 | −Ca | 33 |
| 40.0 | 15.56 | 38.9 | 0.10 | 0 54 | none | 0.64 | 3.11 | −Ca × 4 | 36 |
| 40.0 | 17.24 | 43.1 | 1.54 | 3.20 | none | 4.74 | 1.85 | +S | 38 |
| 40.0 | 14.95 | 37.4 | 1.86 | 4.08 | none | 5.94 | 1.86 | +4S | 41 |
| 40.0 | 15.66 | 39.1 | 0 75 | 2.68 | 0.10 | 3.53 | 1.72 | −S | 42 |
| 40.0 | 14.03 | 35.1 | 0.34 | 0.83 | 0.48 | 1.65 | 2.96 | −S × 4 | 45 |

Increased magnesium, while showing lower total carbohydrates, as compared to the normal, had about the same effect in this respect as increased phosphorus. The effect of increasing magnesium apparently is on the accumulation of starch, since only .44% was found in Series 20 and none in Series 23. Increasing magnesium resulted in a tendency to accumulate sucrose and reducing sugars at the expense of starch reduction.

Deficient magnesium has had a more marked effect on the reduction of total carbohydrates than deficient potassium, the decrease being very markedly progressive with the widening of the ratio of magnesium to other elements. This marked decrease, due to deficient magnesium, has been largely due to the elimination of starch.

Increasing calcium has had the most marked effect of reducing carbohydrates of any treatment given and this decrease becomes progressive as the calcium is increased.

Deficient calcium has likewise resulted in decreased carbohydrates, which becomes progressive as the ratio of calcium to other elements becomes greater.

Increasing sulphur has also resulted in carbohydrate reduction, but it is difficult to appreciate why a further increase in that element, as in Series 40, should show an increase as compared to Series 38.

Deficient sulphur shows a progressive reduction mainly at the expense of sucrose.

An examination of the data for total nitrogen would indicate that increasing the potassium, magnesium or sulphur beyond the amounts supplied in the normal solution has had little, if any, effect on the nitrogen accumulation in the plant. On the other hand, increasing the concentration of phosphorus shows a distinct tendency to increase the accumulation of nitrogen. Likewise increasing the concentration of calcium exhibits an equal tendency towards accumulation of nitrogen.

The omission of potassium, phosphorus and calcium have all resulted in an increase in nitrogen accumulation. On the other hand, the omission of sulphur or magnesium has not affected nitrogen accumulation.

In Series 9, 18, 27, 36 and 45 we have a group of series in which the nitrogen concentration of the feeding solution has been increased fourfold in the absence of one of the essential elements.

The maximum accumulation of nitrogen has taken place in the absence of potassium, with the absence of magnesium having the next most pronounced results. In the absence of phosphorus the increased additions of nitrogen to the ration has not added to the accumulation of nitrogen in the plant. This brings out an interesting situation. It has been shown elsewhere (*1*) that increases in nitrogen concentration, when accompanied by increases in mineral concentration, have resulted in more vigorous and more productive plants. In unpublished data in connection with tomatoes it has been found that excess nitrogen effects can be practically overcome by increasing the potassium ration, but that increasing the phosphorus ration fails to eliminate the excess nitrogen symptoms. In other words, it would appear that deficient potassium actually permits of a greater intake of nitrogen, and that deficient phosphorus has very little effect in that direction. Conversely, the evidence at hand would suggest that the presence of potassium tends to limit nitrogen intake, whilst phosphorus tends to augment it.

## ASH ANALYSIS

In analyzing the ash of plant material in this project, generally recognized methods from various sources were combined to give what seemed to be a satisfactory procedure.

Table 4 gives the results from the analysis of leaves gathered in the Fall of 1931.

Table 4B gives the results of leaves gathered from a duplicate experiment in the Summer of 1931 after fruiting.

TABLE 4.—ANALYSES OF LEAVES GATHERED IN THE FALL OF 1931

| Series | Treatment | Dry matter in fresh weight | Ash in dry matter | Ash constituents as % ash | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | CaO | MgO | $K_2O$ | $P_2O_5$ | $SO_4$ |
| 1 | Normal | 36.1 | 5.81 | 28.31 | 6.93 | 23.05 | 5.98 | 2.91 |
| 2 | +K | 35.5 | 6 79 | 27.09 | 5.9 | 30.27 | 6.28 | 2 46 |
| 3 | +2K | 35.6 | 7 49 | 24.47 | 5.64 | 30.99 | 5.79 | 2.50 |
| 4 | +3K | 35 8 | 6.64 | 17.42 | 5.20 | 37.01 | 6.18 | 3.51 |
| 5 | +4K | 34.3 | 6.50 | 21.78 | 5.28 | 37.65 | 5.38 | 2.68 |
| 6 | −K | 39.2 | 4 88 | 41 24 | 13.91 | 7.84 | 10.51 | 4 75 |
| 7 | −K×2 | 35.6 | 4 84 | 33 70 | 14.61 | 10.78 | 16.60 | 5.97 |
| 8 | −K×3 | 32.7 | 4 98 | 31.71 | 15.34 | 10.57 | 18.62 | 6 13 |
| 9 | −K×4 | 34.7 | 5.23 | 28.18 | 14.32 | 13 56 | 15.16 | 5.16 |
| 10 | −K×6 | 30 7 | 5.46 | 29.75 | 16.72 | 9.45 | 23.73 | 6.08 |
| 11 | +P | 36 6 | 6.29 | 32.29 | 8 71 | 20.16 | 8 64 | 2 93 |
| 12 | +2P | 36.2 | 4 96 | 33.97 | 8 46 | 19.25 | 9.54 | 2.49 |
| 13 | +3P | 36.3 | 6.37 | 28 56 | 8.25 | 21.51 | 9.34 | 2 92 |
| 14 | +4P | 37.1 | 6.06 | 32.60 | 8.44 | 21.27 | 11.60 | 2.87 |
| 15 | −P | 38 30 | 6 40 | 25 30 | 6 73 | 31 36 | 3 53 | 3.22 |
| 16 | −P×2 | 41.50 | 6 42 | 23.27 | 5 62 | 34 74 | 3.53 | 3.04 |
| 17 | −P×3 | 43.80 | 5 82 | 19.24 | 6 04 | 43.11 | 3.65 | 3.30 |
| 18 | −P×4 | 40 80 | 6 36 | 20 14 | 6.22 | 39.05 | 3.78 | 3 18 |
| 19 | −P×6 | 37.8 | 7.96 | 20 50 | 7 34 | 37.62 | 6 91 | 4 10 |
| 20 | +Mg | 36.9 | 6.01 | 31.66 | 9 08 | 26.17 | 7.51 | 3 51 |
| 21 | +2Mg | 35.6 | 8.51 | 27.57 | 9.71 | 22.70 | 6.75 | 2.81 |
| 24 | −Mg | 36.8 | 6.18 | 32 32 | 6 29 | 27 86 | 7.42 | 2.71 |
| 25 | −Mg×2 | 35 4 | 6 43 | 32 76 | 5 81 | 28.14 | 7.92 | 2 46 |
| 26 | −Mg×3 | 32 1 | 7 15 | 24 22 | 4 87 | 28.41 | 8 80 | 3.85 |
| 27 | −Mg×4 | 29.9 | 7.43 | 26 53 | 5.16 | 27.06 | 10 37 | 4 54 |
| 28 | −Mg×6 | 29 5 | 7 80 | 23 92 | 4 37 | 31.17 | 9 68 | 3 76 |
| 29 | +Ca | 37 7 | 6.41 | 32.93 | 7.24 | 24.33 | 7.34 | 2.68 |
| 30 | +2Ca | 37.6 | 6.25 | 34 18 | 6 74 | 23.58 | 6.57 | 2.68 |
| 31 | +3Ca | 35.1 | 6.21 | 36.57 | 6.67 | 23.88 | 7.00 | 2.51 |
| 32 | +4Ca | 34.7 | 7.08 | 33 81 | 6.32 | 22.96 | 6 37 | 2.77 |
| 33 | −Ca | 38.9 | 6.23 | 27.04 | 8.42 | 22.76 | 6.22 | 2.98 |
| 34 | −Ca×2 | 35.6 | 6.02 | 24.38 | 9.52 | 29.45 | 8.45 | 3.92 |
| 35 | −Ca×3 | 30.0 | 6.93 | 23.46 | 9 31 | 28.64 | 9.52 | 3.40 |
| 36 | −Ca×4 | 32.8 | 6.76 | 17.86 | 9.0 | 34.68 | 11.06 | 4.66 |
| 37 | −Ca×6 | 29.2 | 7.50 | 14.5 | 8.27 | 37.01 | 10.27 | 4.06 |
| 38 | +S | 34.9 | 6.77 | 26.1 | 8.06 | 25.09 | 6.77 | 2.89 |
| 39 | +2S | 37.3 | 6.22 | 31.91 | 7.35 | 26.81 | 6.65 | 3.0 |
| 40 | +3S | 38.2 | 6.28 | 29.35 | 8.10 | 26.28 | 7.21 | 2.81 |
| 41 | +4S | 37.3 | 6.37 | 26.80 | 8 29 | 25.58 | 6.63 | 3.44 |
| 42 | −S | 37.3 | 6.95 | 34.16 | 6.97 | 23.11 | 4.85 | 2.61 |
| 43 | −S×2 | 32.9 | 6.95 | 26.19 | 6.30 | 26.79 | 7.70 | 3.05 |
| 44 | −S×3 | 31.4 | 7.58 | 22.76 | 7.11 | 30.68 | 10.24 | 3.45 |
| 45 | −S×4 | 30.6 | 7.98 | 24.16 | 6.37 | 28.18 | 10.16 | 3.42 |
| 46 | −S×6 | 30.1 | 8.35 | 23.58 | 6.66 | 29.56 | 12.58 | 2.71 |

TABLE 4B.—ANALYSES OF LEAVES GATHERED FROM A DUPLICATE EXPERIMENT IN THE SUMMER OF 1931 AFTER FRUITING

| Series | Treatment | Dry matter in fresh weight | Ash in dry matter | Ash constituents as % ash | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | CaO | MgO | $K_2O$ | $P_2O_5$ | $SO_4$ |
| 1 | Normal | 30 0 | 5 25 | 32 97 | 14 49 | 21 85 | 8 44 | 9 48 |
| 2 | Normal + K | 31 9 | 5 30 | 28 21 | 10 89 | 27 19 | 7 24 | 7 01 |
| 3 | Normal + 2K | 30 0 | 5 93 | 23 10 | 8 86 | 31 20 | 6 48 | 5 28 |
| 4 | Normal + 3K | 28 9 | 6 75 | 21 04 | 7 48 | 39 30 | 5 66 | 4 97 |
| 5 | Normal + 4K | 30 5 | 7 08 | 19 15 | 7 15 | 36 97 | 5 27 | 4 91 |
| 6 | Normal − K | 35 0 | 5 25 | 39 43 | 19 55 | 10 66 | 9 34 | 17 98 |
| 12 | Normal + 2P | 31 5 | 4 89 | 31 46 | 17 22 | 17 81 | 13 68 | 7 33 |
| 13 | Normal + 3P | 32 1 | 5 21 | 30 97 | 13 61 | 16 51 | 14 80 | 7 61 |
| 24 | Normal − Mg | 33 7 | 4 62 | 34 35 | 10 84 | 21 76 | 7 69 | 7 66 |
| 25 | Normal − Mg × 2 | 37 4 | 5 46 | 30 92 | 10 77 | 23 55 | 10 00 | 9 93 |
| 29 | Normal + Ca | 35 0 | 6 27 | 31 60 | 11 10 | 12 37 | 6 73 | 6 18 |
| 31 | Normal + 3Ca | 31 4 | 6 13 | 38 11 | 9 85 | 17 70 | 7 99 | 7 50 |
| 32 | Normal + 4Ca | 32 7 | 6 29 | 38 13 | 9 20 | 15 05 | 7 50 | 4 93 |
| 33 | Normal − Ca | 35 0 | 4 73 | 22 63 | 13 41 | 23 80 | 8 22 | 7 32 |
| 34 | Normal − Ca × 2 | 36 7 | 4 72 | 23 31 | 15 74 | 25 29 | 11 48 | 8 64 |
| 35 | Normal − Ca × 3 | 35 8 | 4 79 | 20 63 | 16 11 | 26 57 | 14 38 | 8 39 |
| 36 | Normal − Ca × 4 | 35 1 | 4 87 | 22 99 | 17 85 | 34 59 | 14 60 | 12 05 |
| 40 | Normal + 3S | 33 1 | 5 36 | 22 99 | 11 75 | 25 43 | 7 43 | 6 95 |
| 42 | Normal − S | 31 4 | 5 55 | 31 49 | 15 09 | 21 33 | 7 54 | 6 47 |

TABLE 5.—PER CENT OF EACH ELEMENT IN DRY MATTER SHOWN IN TABLE 4B, EXPRESSED IN TERMS OF PER CENT OF THE AMOUNT FOUND IN THE NORMAL SERIES

| Series No | Treatment | CaO | MgO | $K_2O$ | $P_2O_5$ | $SO_4$ |
|---|---|---|---|---|---|---|
| 1 | Normal | 100 0 | 100 0 | 100 0 | 100 0 | 100 0 |
| 2 | Normal + K | 86 1 | 75 0 | 148 7 | 86 7 | 74 5 |
| 3 | Normal + 2K | 79 2 | 68 4 | 160 7 | 86 7 | 62 8 |
| 4 | Normal + 3K | 82 1 | 65 8 | 257 3 | 86 0 | 67 2 |
| 5 | Normal + 4K | 78 6 | 65 8 | 226 9 | 83 7 | 69 8 |
| 6 | Normal − K | 115 6 | 132 9 | 48 1 | 109 5 | 187 5 |
| 12 | Normal + 2P | 88 4 | 110 5 | 75 6 | 150 3 | 71 8 |
| 13 | Normal + 3P | 93 1 | 92 1 | 74 7 | 173 8 | 79 5 |
| 24 | Normal − Mg | 91 9 | 65 8 | 87 9 | 79 9 | 71 1 |
| 25 | Normal − Mg × 2 | 97 6 | 76 3 | 112 1 | 120 1 | 108 8 |
| 29 | Normal + Ca | 114 4 | 90 8 | 66 9 | 94 8 | 77 6 |
| 31 | Normal + 3Ca | 134 6 | 78 8 | 93 8 | 110 6 | 92 4 |
| 32 | Normal + 4Ca | 138 7 | 76 3 | 82 6 | 106 1 | 62 2 |
| 33 | Normal − Ca | 61 8 | 82 9 | 97 3 | 88 0 | 69 4 |
| 34 | Normal − Ca × 2 | 63 6 | 97 3 | 103 4 | 122 3 | 81 9 |
| 35 | Normal − Ca × 3 | 57 1 | 101 3 | 110 4 | 155 7 | 80 5 |
| 36 | Normal − Ca × 4 | 64 7 | 114 4 | 146 1 | 160 3 | 117 8 |
| 40 | Normal + 3S | 71 1 | 82 9 | 118 2 | 88 0 | 74 9 |
| 42 | Normal − S | 101 1 | 110 5 | 102 6 | 94 3 | 72 1 |

Table 4 gives the results of the ash analysis of the leaves in terms of ash constituents and dry matter constituents.

Table 5 gives the results of the composition of dry matter of Table 4B expressed in per cent of the amount of the respective element found in the normal series. Plates 1 to 3 portray these results graphically. From an examination of these figures and tables, the following facts emerge; these will be discussed and interpreted later.

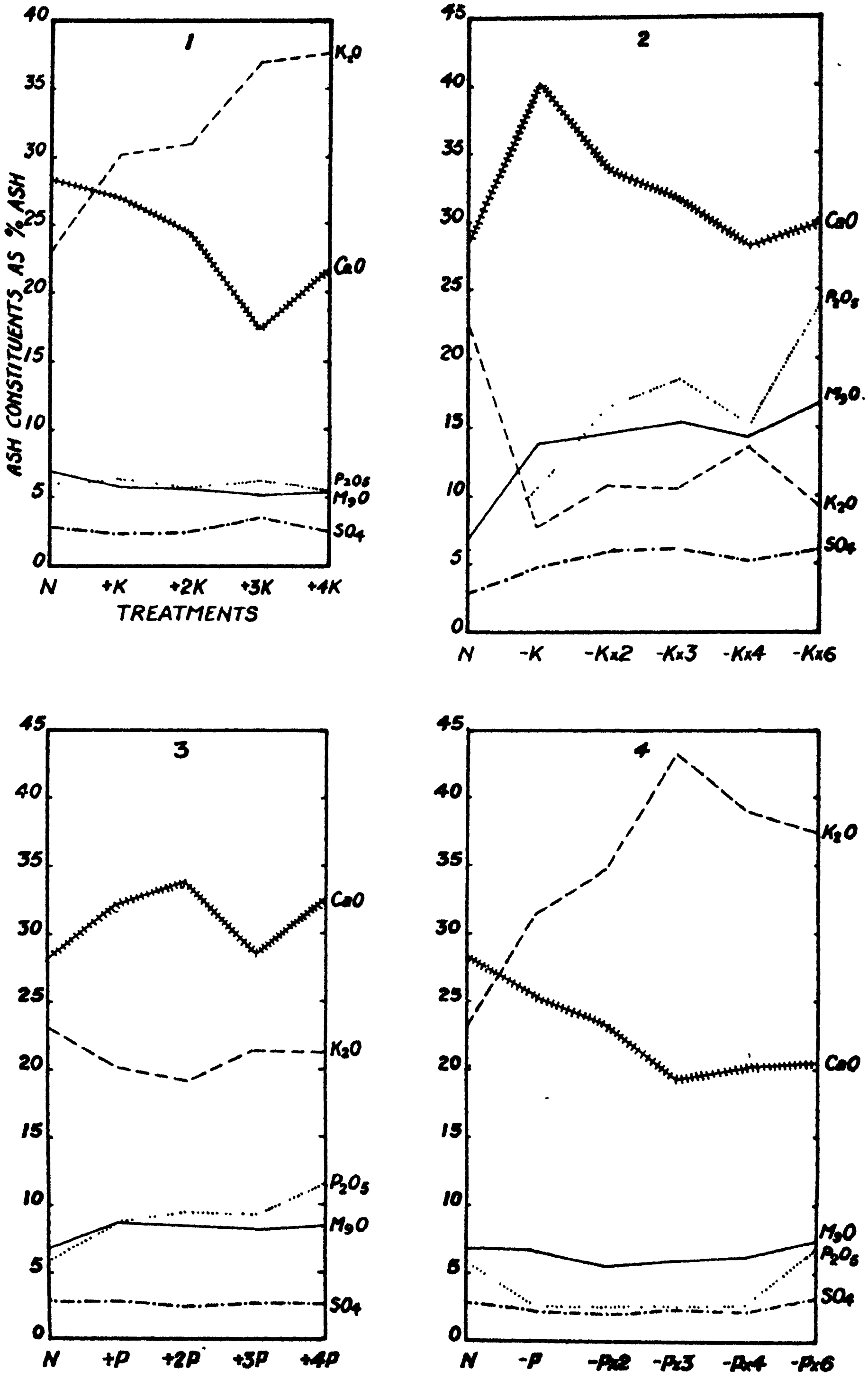
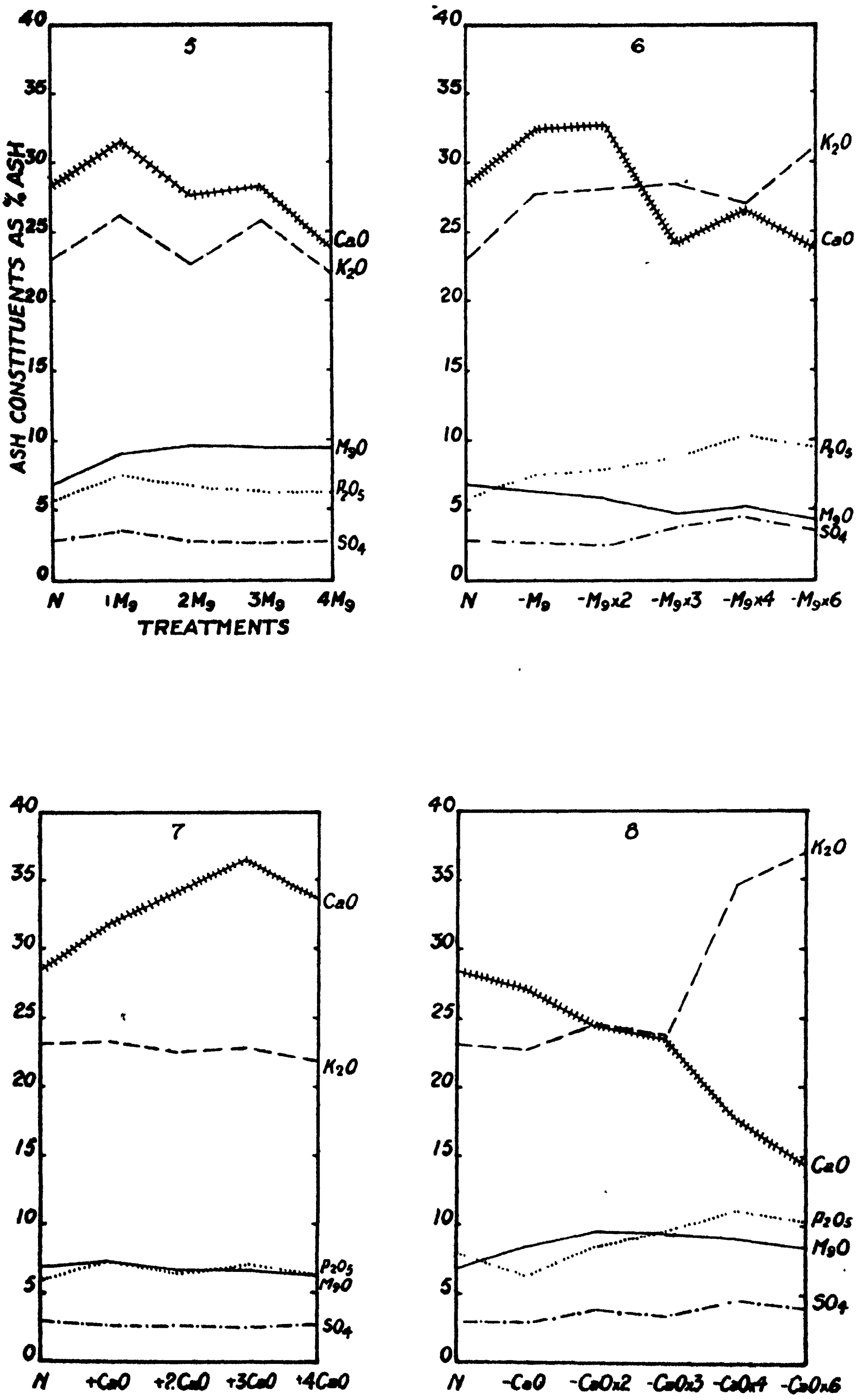

1
ASH CONSTITUENTS AS % ASH
0
5
10
15
20
25
30
35
40
K₂O
CaO
P₂O₅
MgO
SO₄
N
+K
+2K
+3K
+4K
TREATMENTS
2
0
5
10
15
20
25
30
35
40
45
CaO
P₂O₅
MgO.
K₂O
SO₄
N
-K
-Kx2
-Kx3
-Kx4
-Kx6
3
0
5
10
15
20
25
30
35
40
45
CaO
K₂O
P₂O₅
MgO
SO₄
N
+P
+2P
+3P
+4P
4
0
5
10
15
20
25
30
35
40
45
K₂O
CaO
MgO
P₂O₅
SO₄
N
-P
-Px2
-Px3
-Px4
-Px6

PLATE 1


5
ASH CONSTITUENTS AS % ASH
40
35
30
25
20
15
10
5
0
CaO
K2O
MgO
P2O5
SO4
N
1Mg
2Mg
3Mg
4Mg
TREATMENTS
6
K2O
CaO
P2O5
MgO
SO4
N
-Mg
-Mgx2
-Mgx3
-Mgx4
-Mgx6
7
CaO
K2O
P2O5
MgO
SO4
N
+CaO
+2CaO
+3CaO
+4CaO
8
K2O
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P2O5
MgO
SO4
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-CaO
-CaOx2
-CaOx3
-CaOx4
-CaOx6

PLATE 2

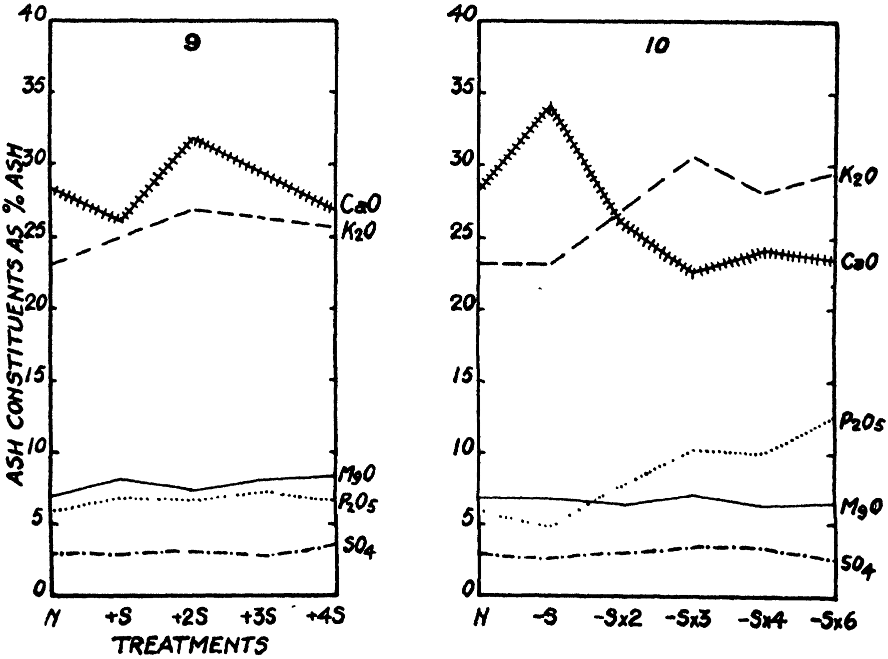

PLATE 3

The addition of potassium to the normal solution has resulted in a progressive increase in $K_2O$ accumulation in both ash and dry matter. There has been an almost corresponding decrease in calcium in both ash and dry matter for both experiments; a reduced accumulation of magnesium in both experiments; no definite trend in $P_2O_5$ in Table 4 but a definite decrease in Table 4B and a decrease in sulphur accumulation in both experiments.

The withdrawal of potassium from the normal solution has resulted in a very marked decrease in $K_2O$ in both ash and in dry matter, accompanied by a marked increase in CaO in ash and dry matter; a marked increase in MgO in both ash and dry matter, and an increase in $P_2O_5$ and $SO_4$ in both ash and dry matter.

Increased feeding of phosphorus has resulted in a marked increase of that element in both ash and dry matter; a decrease in the amount of $K_2O$ in both ash and dry matter; an increase in calcium in both ash and dry matter in Table 4 only; and an increase in MgO in both ash and in dry matter. The further increments in phosphorus feeding have still further added to the increase of that element in both ash and in dry matter, with no definite trend in $K_2O$, CaO, MgO or $SO_4$ accumulation.

The complete withdrawal of phosphorus from the normal solution has resulted in a marked decrease of that element in both ash and in dry matter; a marked increase in $K_2O$ in ash and in dry matter, a decrease in CaO in ash and in dry matter; no marked change in MgO or $SO_4$ until the nitrogen concentration becomes very high where an increase in MgO and $SO_4$ is observed, which is correlated with a marked increase in ash and in dry matter.

Increasing magnesium in the normal solution, as shown in Table 4, has resulted in increased MgO in both ash and dry matter; increased CaO and increased $K_2O$ in both ash and in dry matter; and increased $P_2O_5$ and increased $SO_4$ in both ash and in dry matter. This analysis appears dubious as it is difficult to imagine an increase in the per cent of all bases.

The complete withdrawal of magnesium has resulted in a decrease in MgO in both ash and in dry matter; an increase in both CaO and $K_2O$ in ash and in dry matter; and an increase in $P_2O_5$ in ash and in dry matter, with a decrease in $SO_4$ in both ash and in dry matter.

The further increase of the concentration of elements, other than magnesium, has resulted in a further decrease in MgO in ash and in dry matter; an increase in $K_2O$ in ash and in dry matter; and a very marked increase in $SO_4$ and $P_2O_5$ in ash and in dry matter, with no further effect on CaO accumulation.

The feeding of excess calcium has resulted in a higher CaO figure in ash and in dry matter; little change in $K_2O$ in ash in Table 4 but a drop in Table 4B; a lower figure for dry matter in both experiments; lower MgO in dry matter; lower $SO_4$ in ash and in dry matter; and higher $P_2O_5$ in ash and in dry matter in Table 4; but lower $P_2O_5$ in Table 4B, where the treatment has been prolonged. Further increments in calcium feeding have added further to the amounts of CaO in ash and in dry matter, with a reduction in MgO in ash and $K_2O$ in ash but not in dry matter, due to higher figures for ash in dry matter. The figures for $P_2O_5$ and $SO_4$ have been little altered.

The complete withdrawal of calcium has not materially affected any figures except those for MgO in Table 4, where an increase of MgO in ash and in dry matter is recorded, but in Table 4B there has been an increase in $K_2O$ with a decrease in CaO.

The further increase of the concentrations of elements, other than calcium, has given a much lower figure for CaO, accompanied by a very large increase in $K_2O$ in ash and in dry matter; and an increase in MgO, $SO_4$ and $P_2O_5$ in ash and in dry matter.

The addition of excess sulphur to the normal in Table 4, has resulted in higher figures in ash and in dry matter for $K_2O$, MgO, $P_2O_5$ and $SO_4$, with a lower figure for CaO. Further additions of sulphur have not tended to bring about any further material alterations in the above relationship, except in higher values for MgO and $SO_4$.

The complete withdrawal of sulphur from the normal solution has resulted in a higher figure for CaO in ash and in dry matter and a lower figure for $P_2O_5$ in ash and in dry matter.

Further increases in the elements, other than sulphur, have resulted in a marked increase in $K_2O$ and MgO in dry matter and a marked increase in $P_2O_5$ in both ash and in dry matter.

## DISCUSSION

From a consideration of the foregoing results, there are certain outstanding facts which are clearly evident and a few instances difficult to explain. In the first place, the antagonistic relation between Ca and K is fully apparent; as one falls the other tends to increase. This is more evident in the deficient groups than in the excess groups. Where potassium is actually in excess it has certainly reduced CaO accumulation, but excess calcium has not always brought about a marked reduction in $K_2O$ until prolonged subjection to this treatment. This antagonism or negative correlation between Ca and K has been reported by the senior author (*2*). The same relationship between K and Mg was also reported (*2*), but is more marked in these experiments with the strawberry. The outstanding relationship, which is somewhat different from that found in apples (*2*), is the relation existing between phosphorus and potassium. The complete withdrawal of potassium has resulted in a very marked increase in $P_2O_5$ accumulation, which is entirely opposite to that reported (*2*) and also opposite to that reported by Thomas (*3*). These results are more in accord with those reported by Lagatu and Maume wherein the omission of potassium from a fertilizer resulted in increased absorption of phosphorus.

Lagatu and Maume have advanced that their results are contradictory to Liebig's Law of the Minimum, which predicates decreased absorption of the remaining elements where one is present below the critical concentration. Thomas (*3*) has sought to show that in reality Lagatu and Maume's results are not actually contradictory and postulates that "the omission of an element already abundant in the soil from a fertilizer results in increased absorption by the plant of the remaining elements added in the fertilizer relative to the absorption of these elements from the complete fertilizer plot until the element omitted from the fertilizer becomes a limiting factor, *i.e.*, until its concentration is reduced below the limiting concentration."

In the results here reported, while we can only show the relative amounts of each element found in ash and in dry matter, the fact stands out that the complete withdrawal of potassium has certainly resulted in an increased amount of $P_2O_5$ found in the plant.

The other side of the story, namely, the addition of K, has evidently not tended to prevent or interfere with $P_2O_5$ accumulation until fed for a prolonged period as in Table 4B; conversely, increased phosphorus feeding has retarded potassium accumulation. Thus, excess $P_2O_5$ has at least tended to reduce the potassium found in the ash to a slight degree and the complete withdrawal of phosphorus has very markedly increased the amount of $K_2O$ found.

On the limiting side these experiments deal only with the complete withdrawal of an element, or, in other words, something more than a deficiency, as they were designed primarily to obtain information of diagnostic value and extremes were sought for that purpose.

In Table 4A will be found the analyses from a different series of plants, in which potassium, phosphorus, calcium, magnesium and sulphur were merely deficient in the following way: take the two deficient phosphorus series; the one designated as 2 deficient P received all elements except P in twice a normal application, with P supplied in normal amount; 4 deficient P received all elements except P at four times normal strength and P in normal amounts; the same designations apply to the other deficient series.

An examination of this table reveals that deficient K has tended to increase $P_2O_5$ accumulation exactly as did its complete withdrawal; and that deficient phosphorus has resulted in a distinct tendency towards an increase in $K_2O$, as did its complete withdrawal.

TABLE 4A.—SHOWING ASH ANALYSES FROM A GROUP OF PLANTS IN WHICH THE ELEMENTS WERE MERELY DEFICIENT

| Treatment | Series No. | CaO | $K_2O$ | MgO | $P_2O_5$ |
|---|---|---|---|---|---|
| | | % | % | % | % |
| Normal × 2 | 1 | 29.40 | 20.22 | 8.72 | 13.34 |
| 2 Def. K | 7 | 32.29 | 20.29 | 13.60 | 18.89 |
| 2 Def. P | 16 | 23.80 | 23.84 | 7.33 | 8.80 |
| 4 Def. P | 18 | 21.34 | 29.69 | 8.02 | 8.41 |
| 2 Def. Ca | 34 | 26.78 | 22.69 | 10.99 | 14.08 |
| 4 Def. Ca | 36 | 25.23 | 23.11 | 10.16 | 13.73 |
| 4 Def. Mg | 27 | 23.85 | 28.43 | 6.03 | 16.48 |
| 4 Def. S | 45 | 24.25 | 25.78 | 7.60 | 18.00 |

There would appear to exist in these experiments a negative relationship between $P_2O_5$ and $K_2O$, or, in other words, antagonism.

From the above facts, namely, that there exists a negative correlation between Ca and K and K and $P_2O_5$, we should expect a positive correlation to be found between $P_2O_5$ and Ca. This is partly evident in Table 4, where Ca and P have been completely withdrawn. We note that decreased accumulation of Ca results in the absence of phosphorus feeding and gets progressively less as the amount of Ca is increased in the feeding solutions, in the absence of phosphorus. In other words, when phosphorus is limiting the plant does not take up as liberal amounts of calcium. Increasing the $P_2O_5$ in the feeding solution has resulted in some increase in amount of CaO absorbed. On the other side, increased calcium feeding has resulted in slight increases in $P_2O_5$ in Table 4 but not in Table 4B where the high potassium concentration in the nutrient solution has tended to limit the $P_2O_5$ intake; but the withdrawal of calcium from the feeding solution has not, as we might expect, brought about a lower accumulation of $P_2O_5$ but rather an increase in the accumulation of that element.

Turning now to Table 4A we note confirmation of the fact that low or decreased Ca has resulted in increased $P_2O_5$, but that there is no increase in the $P_2O_5$ found in Series 16 over that of 18, where the amount of phosphorus fed was one-quarter that of the other.

There are certain outstanding points from the ash analyses which correlate to a degree with the foliage conditions and appearance of the plants.

In the first place the normal series exhibited signs of certain deficiencies which indicated either deficient phosphorus, potassium or both; secondly, the plants in the deficient calcium group and the deficient sulphur group were, during the major part of the season, free of any signs of deficient symptoms and exhibited the best vigour of any series until quite late in summer, when slight signs of calcium and sulphur deficiency were exhibited; and thirdly, the deficient magnesium group were almost as vigorous and were also free of deficient symptoms until quite late, when deficient magnesium symptoms were exhibited.

An examination of the data from these three groups of plants reveals certain things in common. Thus, they are all higher in potassium, excepting 33 and 42, which two series did not compare as favourably with the others of the groups. Again, they are all higher in $P_2O_5$ than the normal. We have thus a high potassium and high phosphorus content, associated with increased vigour and lack of deficient symptoms for the major part of the season.

In other groups, such as the increased potassium group, we can associate the large amount of purpling with lower $P_2O_5$, and deficient potassium of the −K groups with the burning and flagging of the foliage. In the excess phosphorus groups the low $K_2O$ content may be associated with the scorch and lack of vigour of the plant. The low $P_2O_5$ content of the deficient phosphorus group is definitely associated with the bronzing and purpling of the foliage.

In the higher excess magnesium series the foliage scorch can be associated with a slightly lower $K_2O$ content and the purple bronzing with the low $P_2O_5$, the same as in the normal series. The excess calcium group affords an opportunity for the raising of a pertinent question. In this group especially in the higher series, considerable scorch was observable in all experiments and would lead to the suspicion that low potassium was to be found. As the analyses reveal, however, the potassium is not lower in Table 3 than in the normal, but the calcium is higher. The scorch, therefore, is associated here with high calcium and a wide ratio between calcium and potassium.

An examination of the other groups reveals that this can also be said of them, namely, that the scorch condition of the low potassium series is associated with a high calcium content of the leaf. This is true in the low K group, and the high Ca group, where scorch was most noticeable. In a similar way the purplish colour of deficient phosphorus is associated in the groups with a low $P_2O_5$ content, such as in the normal, the higher potash group, the low $P_2O_5$ group, high magnesium group, the high Ca group and the high sulphur group. Conversely, the absence of these purplish and bronze tints may be associated with a high $P_2O_5$ content, as in the low K group, the high phosphorus group, the low magnesium group, the low calcium group and the low sulphur group. In other words, a fairly close association between symptomatic diagnosis and ash analysis is apparent, sufficient to warrant a further investigation along these same lines.

## CORRELATIONS

Reference has already been made to apparent negative and positive correlations which exist in the amounts of certain elements found in the ash. The data under discussion have been arranged in the form of correlation tables and the result of this treatment is interesting.

These tables are not given but it may be pointed out that a very significant negative correlation between CaO and $K_2O$ is found of −.6724 ±.049. This is in full accord with Davis (*2*) and bears out the evidence submitted on this experiment so far.

The positive correlation of +.5431 ±.063 between MgO and $P_2O_5$ is in accord with the small positive correlation found by Davis (*2*) which was not accepted as significant. In this case, however, a correlation of this magnitude can hardly be ignored.

The positive correlation of +.3191 ±.080 between CaO and MgO is not in accord with Davis (*2*) where practically no correlation existed. It might be well to bear in mind in this connection that in these experiments, while the complete withdrawal of certain elements was undertaken, as in Davis' work, there was, in addition, excess feeding of each element and in a few cases merely deficient feeding so that less extreme cases are included in the analyses.

The significant negative correlation between $K_2O$ and MgO of −.6893 ±.047 is very marked and is equal to that for $K_2O$ and CaO.

The negative correlation already referred to between $P_2O_5$ and $K_2O$ is fully borne out by the figure −.4979 ±.067 and fully establishes that tendency in these experiments.

The positive correlation between CaO and $P_2O_5$, already mentioned as being expected or deducable from the established relationships between the other elements, is partially corroborated by the positive correlation of +.1103 ±.088, although this figure is not fully significant.

We thus find the following significant negative correlations:—

$K_2O$ and CaO −.6724 ±.049
$K_2O$ and MgO −.6893 ±.047
$K_2O$ and $P_2O_5$ −.4979 ±.067

and the following significant positive correlations:

CaO amd MgO +.3191 ±.080
MgO and $P_2O_5$ +.5431 ±.063

and the doubtful positive correlation:

CaO and $P_2O_5$ of +.1103 ±.088.

Since figures for nitrogen content are not available for all series it is not possible to correlate the amount of nitrogen found with the amounts of other elements. It is possible, however, to examine the correlations between the amount of nitrogen fed and the amount of any particular element found in ash. There are apparently significant positive correlations between nitrogen fed and the amount of potassium in ash and phosphorus in ash, and a positive correlation of doubtful significance between nitrogen fed and magnesium found. There is a highly significant negative correlation between the amount of nitrogen fed and calcium found. In other words, high nitrogen feeding tends to increased absorption of potassium and phosphorus and possibly magnesium and to decreased absorption of calcium.

## SUMMARY

1. Strawberry plants were grown in sterile sand in pots and subjected to the following nutrient treatments: complete nutrient, excessive potassium, deficient potassium, excess and deficient phosphorus, excess and deficient magnesium, excess and deficient calcium, and excess and deficient sulphur.

2. Foliage symptoms were obtained which could be correlated with the treatments given and which should prove of value in diagnosis.

3. Lack of hardiness during winter was associated more markedly with deficient potassium than with any other treatment.

4. Yield data indicate the possibility of reduced fruit bud formation due to excess phosphorus and excess calcium feeding.

5. The complete withdrawal of phosphorus and magnesium markedly affected fruit bud formation, while the complete withdrawal of calcium and sulphur had little, if any, affect.

6. The plants appeared capable of reutilizing their original potassium to a marked degree.

7. Carbohydrate analyses of the tops (leaves and crowns) indicated the marked influence of potassium in carbohydrate accumulation.

8. Ash analyses of the leaves revealed the marked influence on the composition of ash and dry matter of the various treatments.

9. All omission treatments were reflected by a reduction of the element concerned in ash and in dry matter.

10. Antagonism between calcium and potassium and phosphorus and potassium was revealed.

11. Lack of low potassium and low phosphorus symptoms of the foliage were noted in the series where calcium, magnesium or sulphur were not fed and this was associated with a high for those two elements found in ash and in dry matter.

12. Correlation figures are presented to show significant correlations as follows: a negative correlation between CaO and $K_2O$ in ash; a positive correlation between MgO and $P_2O_5$; a negative correlation between $K_2O$ and MgO, and a negative correlation between $P_2O_5$ and $K_2O$ in ash.

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# VARIATION OF SEX DIFFERENCE IN CHICK GROWTH

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[Received for publication March 10, 1934]

As a general rule in work dealing with growth in poultry individual weekly weights are secured. This is usually the case whether the nutritional or genetic aspects of growth are under consideration. These figures are generally segregated and presented as weekly mean male and female weights, more often with, sometimes without indications of variability. Frequently such data are not further elaborated upon, while in other instances the male and female weights are again grouped together and either in tabular or graphic form presented as general averages. In still other cases the weights of one sex may be treated with one or another conversion factor in order to make them of comparable value to those of the opposite sex, whereafter they are considered as such. In this instance the object is either to give a general idea of growth in a particular breed or cross, to demonstrate the success or otherwise of a particular treatment, or it is frankly done so that paucity in numbers will not interfere with adequate statistical treatment of the data.

Schroeder and Lawrence (*4*) have determined the number of individuals necessary to secure even mathematical chances that a test may be duplicated with approximately the same results. This requirement presupposes a difference between the means of test and control lots of three times the standard error of the difference. However, in view of Fisher's (*1*) commonly adopted suggestion that adequate security is obtainable in this type of work with odds of 1 in 20, the numbers determined by the first mentioned authors become unnecessarily conservative for practical purposes. On the other hand, these authors state that the numbers required must be of one sex. Presumably this requirement must be understood as necessitated by the sex-different rate of growth and absolute growth, which in mixed populations would produce non-normal distributions, to which the ordinary tests of significance could not be applied.

It is the purpose of the present paper to demonstrate that the well known sex' difference in growth in chickens, which, presumably, is regarded as a fairly stable phenomenon, in reality may be influenced to such extent by varying nutritional regimes that, in most instances, it will not be sound practice to treat male or female weights with conversion factors in order to facilitate their ultimate comparability.

## DATA

For the purpose of a nutritional experiment, to be later reported upon, 991 eggs were set from mature Barred Plymouth Rock females that had been mated to Single Comb White Leghorn males in flock matings. Hatchability proved to be 67.5% of the total eggs set, and the chicks were segregated according to sex by the method of Warren (*5*) at four periods during the actual hatch, which occurred during the twenty-four hours of the 20th day of incubation. From the two sex groups two pens were

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[1] Poultry Husbandman.

TABLE 1.—DIFFERENCES OF MEANS BETWEEN PENS AND SEXES AND THE STATISTICAL SIGNIFICANCE OF THESE DIFFERENCES, ALSO PER CENT RELATION OF MEANS

| — | | (1) Difference between means | (2) Probable occurrence of such difference by chance | (3) A weight as per cent of B weight | (4) Difference between means | (5) Probable occurrence of such difference by chance | (6) A weight as per cent of B weight |
|---|---|---|---|---|---|---|---|
| Weeks | | A ♂ and B ♂ | | | A ♀ and B ♀ | | |
| | | Grams | % | | Grams | % | |
| Initial | 11/7 | .112 ± .514 | 82 6 | 110 3 | .100 ± .448 | 98.4 | 100.3 |
| 1st | 18/7 | 2.388 ± 1 057 | 2 3 | 96.0 | 1 860 ± 1.021 | 6.9 | 103.4 |
| 2nd | 25/7 | .384 ± 2.191 | 85.7 | 99 6 | 3.764 ± 1.764 | 3.4 | 103.1 |
| 3rd | 1/8 | 7.300 ± 3.304 | 2.7 | 94.9 | 2.60 ± 2.902 | 36.8 | 98.2 |
| 4th | 8/8 | 6.180 ± 4.924 | 20 8 | 97 0 | 3.44 ± 4.089 | 40.1 | 101.7 |
| 5th | 15/8 | 10.000 ± 6.379 | 11.7 | 96 7 | 2 28 ± 5.460 | 67.4 | 99.2 |
| 6th | 22/8 | 15.23 ± 8.863 | 8 5 | 96.1 | 3 66 ± 6.779 | 58.9 | 99.0 |
| 7th | 29/8 | 19.32 ± 10 857 | 7 5 | 96 2 | 4.12 ± 7 714 | 59.6 | 99.2 |
| 8th | 5/9 | 27.76 ± 12.654 | 2 9 | 95.6 | 7.98 ± 8 813 | 36.3 | 98.6 |
| | | A ♂ and ♀ | | ♀ weight as per cent of ♂ weight | B ♂ and ♀ | | ♀ weight as per cent of ♂ weight |
| Initial | 11/7 | 1.466 ± .537 | 0.64 | 96.0 | 1 454 ± .457 | 0.15 | 96.1 |
| 1st | 18/7 | .664 ± 1.068 | 53 5 | 98 8 | 4 192 ± 1 010 | 0.0046 | 91 7 |
| 2nd | 25/7 | 2 688 ± 2.025 | 18.4 | 103.0 | .460 ± 1.953 | 81.0 | 99 5 |
| 3rd | 1/8 | 3.34 ± 3 141 | 28 9 | 102.5 | 1.36 ± 3.077 | 66 0 | 99.1 |
| 4th | 8/8 | 7 34 ± 4 589 | 11 0 | 103 6 | 2 28 ± 4 463 | 61 0 | 98.9 |
| 5th | 15/8 | 0 00 ± 5 792 | 100.0 | 100.0 | 7 72 ± 6 083 | 20 4 | 97 4 |
| 6th | 22/8 | 1.35 ± 7.989 | 86 5 | 100 4 | 10 22 ± 7 789 | 19 1 | 97 4 |
| 7th | 29/8 | 8 42 ± 9.168 | 35 8 | 98 3 | 23 62 ± 9 660 | 1 4 | 95 4 |
| 8th | 5/9 | 21 36 ± 10.670 | 4 6 | 96 5 | 41 14 ± 11 213 | .026 | 93 5 |

made up by random choice to contain 284 and 279 birds respectively. Each pen was distributed evenly over 16 compartments of a battery brooder, lots from the two pens alternating and care being taken that each lot contained approximately the same proportion of males to females. Both pens were fed the same all-mash ration. This ration is supposedly well balanced and well fortified with vitamins. The only difference in treatment of the two pens was, as far as we are aware, the extraction of certain presumably toxic elements from the feed of the pen designated "B", the "A" pen serving as normal control.

Mortality to eight weeks of age was fairly low amounting to 6.4 and 5.4% in the A and B pens respectively. As far as could be determined on macroscopic post mortem examination, no fatalities could be correlated to experimental treatment. Most of the deaths occurred during the first few days of the experiment or were due to smothering or in a few cases to cannibalism. A very few cases of "slipped tendon" occurred in each pen.

The chicks were weighed individually 50 to 70 hours after freedom from the shell had been gained, and subsequently every seventh day for eight weeks, nine weighings in all.

In statistical treatment of the data so obtained, it was found that pen A had an initial advantage over pen B of 1.47 grams, which proved to be a significant difference. Shortly, however this advantage disappeared, and by the end of the fifth week the relative positions of the two pens were significantly reversed. By the end of the eighth week the advantage

TABLE 2.—DIFFERENCES OF COEFFICIENTS OF VARIABILITY BETWEEN PENS AND SEXES AND THE STATISTICAL SIGNIFICANCE OF THESE DIFFERENCES

| — | | (1) Difference between C.V.* | (2) Probable occurrence of such difference by chance | | (3) Difference between C.V.* | (4) Probable occurrence of such difference by chance | |
|---|---|---|---|---|---|---|---|
| Weeks | | A ♂ and ♀ | | | B ♂ and ♀ | | |
| | | % | % | | % | % | |
| Initial | 11/7 | 1.33 ± 0.986 | 17.7 | ♂ > ♀ | 0.43 ± 0.898 | 96.0 | ♂ > ♀ |
| 1st | 18/7 | 1.52 ± 1.356 | 26.3 | ♂ < ♀ | 1.32 ± 1.264 | 29.8 | ♂ > ♀ |
| 2nd | 25/7 | 1.70 ± 1.613 | 29.4 | ♂ > ♀ | 5.07 ± 1.554 | 0.118 | ♂ > ♀ |
| 3rd | 1/8 | 0.07 ± 1.653 | 96.8 | ♂ > ♀ | 3.96 ± 1.560 | 1.09 | ♂ > ♀ |
| 4th | 8/8 | 0.70 ± 1.613 | 66.7 | ♂ > ♀ | 5.17 ± 1.553 | 0.096 | ♂ > ♀ |
| 5th | 15/8 | 1.61 ± 1.404 | 25.0 | ♂ > ♀ | 2.77 ± 1.476 | 6.0 | ♂ > ♀ |
| 6th | 22/8 | 2.64 ± 1.506 | 8.0 | ♂ > ♀ | 4.46 ± 1.432 | 0.18 | ♂ > ♀ |
| 7th | 29/8 | 3.29 ± 1.355 | 1.5 | ♂ > ♀ | 4.37 ± 1.386 | 0.16 | ♂ > ♀ |
| 8th | 5/9 | 2.35 ± 1.290 | 6.9 | ♂ > ♀ | 4.64 ± 1.090 | 0.0034 | ♂ > ♀ |
| | | A and B ♂ | | | A and B ♀ | | |
| Initial | 11/7 | 0.144 ± 0.986 | 88.1 | A > B | 0.54 ± 0.899 | 54.9 | A > B |
| 1st | 18/7 | 0.46 ± 1.302 | 72.6 | A < B | 2.38 ± 1.319 | 7.2 | A > B |
| 2nd | 25/7 | 0.94 ± 1.757 | 58.9 | A < B | 2.43 ± 1.389 | 8.0 | A > B |
| 3rd | 1/8 | 0.79 ± 1.714 | 64.6 | A < B | 3.10 ± 1.492 | 3.4 | A > B |
| 4th | 8/8 | 1.29 ± 1.737 | 45.9 | A < B | 3.18 ± 1.415 | 2.4 | A > B |
| 5th | 15/8 | 1.04 ± 1.558 | 50.3 | A < B | 0.12 ± 1.274 | 92.4 | A > B |
| 6th | 22/8 | 0.04 ± 1.652 | 98.4 | A > B | 1.86 ± 1.260 | 13.9 | A > B |
| 7th | 29/8 | 0.60 ± 1.567 | 70.4 | A < B | 0.48 ± 1.141 | 67.4 | A > B |
| 8th | 5/9 | 0.96 ± 1.475 | 51.5 | A < B | 1.33 ± 1.178 | 25.8 | A > B |

of pen B over pen A had become so markedly significant that it was decided to carry as many pullets as possible of each pen over the full coming year.

As the distributions appeared to approach the normal and since the means were very significant the normal distribution curves were calculated on the two actually observed female curves. The $X^2$ test showed in both cases a marked goodness of fit, and a proportionate number of specimens were therefore chosen from each class of the normal distributions to make up 90 birds from pen A and 89 birds from Pen B. The records of the male populations were treated in a similar manner, and it is our belief that samples closely representative of the distribution of the full populations were secured by this treatment. All data presented in Tables 1 and 2 are taken from the records of the sample populations so chosen.

From the figures in Table 1 it may be seen that the A and B females practically had the same growth rate throughout, with a slight advantage for the A birds in the early stages, the relative positions being reversed in the later weeks (column 6). It may further be seen, that, of all the four sex-groups, the B males had the fastest growth throughout (column 3), whereas the A males grew at a similar rate to that of the A females with apparently even a slower growth rate up to the end of the sixth week (column 3).

Thus it is clear that on an analysis of the mean weights, the A males were quite adversely affected by the experimental treatment, while the females of this pen were affected very little. This was further brought out by correlation coefficients, showing relation in body weights of male and female chicks at 50 to 70 hours after hatching to their body weight at 58 to 59 days of age.

### CORRELATION COEFFICIENTS BETWEEN BODY WEIGHT AT HATCHING TIME AND EIGHT WEEKS OF AGE

| | Pen A. | Pen B. |
|---|---|---|
| ♂ | $r = .10 \pm .087$ | $r = .21 \pm .051$ |
| ♀ | $r = .25 \pm .033$ | $r = .21 \pm .049$ |

Although these coefficients are too low to be of practical value, still, with 128 or more degrees of freedom, they are highly significant with the one exception of the one for pen A males which shows no significance.

It would appear from the section of Table 2 showing relation in variability between the presumably normal males and females of pen B, that the variability of growth rate is much greater for the males than the females in this instance. In pen A there was very little to choose as to variability between males and females until six weeks of age at which time there was an indication of a significantly greater variability among the males. Although as previously noted (Table 1) the males of pen A suffered severely in body weight owing to the treatment accorded them they showed no significantly different variability than the males of pen B (Table 2). Conversely the females of pen A show, by this table, significantly greater variability than those of pen B in many instances although as noted their mean growth rate did not suffer from the treatment received.

Thus it is clear that in poultry the sexes respond in a different manner to adverse environmental conditions. In our experiment the males suffered a considerable mean retardation in growth while the treatment apparently affected the females only by increasing their variability. However, from the records published by Warren (*5*), Waters (*6*), Holmes, Pigott and Campbell (*2*), Roberts (*3*), and others, it would appear that this relationship may be reversed. In eight week old chicks "optimum growth" is in each case the response of the inherited rate of growth to whatever may be the most favourable environmental conditions for the particular breed or sex. Hence, it is obvious that results obtained on varying stock and under different environmental regimes will vary as any of several factors may favour or hamper one or the other sex as the case may be.

## SUMMARY

1. The data herein reported would indicate that the normal sex difference in growth rate and absolute growth may be markedly influenced by environmental conditions.

2. It has been shown that in our control lot one sex was affected quite severely, while the opposite sex, subjected to identical treatment, was affected to a slight degree only if at all.

3. It is likewise apparent from our data that this sex-different response would have been lost sight of if the data had been treated as being from a

mixed population, and completely obscured if conversion factors had been used.

4. It has been found that a similar or reversed condition obtained in the data of other workers, and it is therefore concluded that mixed or converted growth data in fowls may be misleading, hence should not be used.

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# YIELD AND QUALITY OF FRUIT FROM STRONGLY VEGETATIVE CONCORD GRAPE VINES

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(Received for publication February 14, 1934)

In the spring of 1929 the Ontario Horticultural Experiment Station commenced a pruning and soil fertilization experiment at the Haines Concord vineyard situated about two miles east of Jordan. Plots are laid out on nine adjacent rows to make three series of three rows each, the series being pruned to 30, 36, and 42 buds. Each plot contains 18 vines, being three rows wide and six vines long. The vines are pruned to the 6-arm Kniffen system. While the soil[3] in this vineyard is quite variable, on the whole, grape growers would consider it a good grape soil of better than average fertility.

Every third plot in each series is a check plot on which no fertilizer of any kind has been applied since the experiment was started in 1929. It is with these untreated plots only that the present paper deals as a complete report on the experiment proper will appear at a later date. Such interesting relations between vigour of vine and yield and quality of fruit have shown up in these plots during the years 1932 and 1933 that an advance report on this particular phase would seem to be justified.

Samples for sugar and acid analysis were taken approximately two weeks before picking and again three days before picking each year. The mean of these two tests was taken as the sugar and acid content of the plot for that particular year. The berries were picked from the bunches, a uniform volume of fruit was squeezed in a Carver laboratory press at 4,000 lbs. pressure and the juice was immediately analyzed for sugar and total acid. Sugar determinations were made by a method given in Sutton's Volumetric Analysis, 10th ed., page 331, and the acid was obtained by the Official Method. Although the method used for sugar determinations includes other reducing substances than sugar the error introduced in giving the total reading as sugar is probably very small.

The data are given graphically in Figure 1. The 27 check plots have been divided into classes based upon their vigour of growth as represented by weight of prunings. Most of the differences in vine vigour have been due to varying soil conditions, but five years' moderately heavy pruning to a constant number of buds for a given series has tended to accentuate these differences. The graph figures show that the vines in the least vegetative plot have averaged 2.1 lb. of prunings per year while the vines in the most vegetative plot have produced an average of 4.6 lb. of prunings. Yield figures are the means per vine per year, and acid and sugar figures are the means per plot per year.

It is of special interest that the weakest growing plots have given grapes of the best quality as measured by sugar and acid in the juice,

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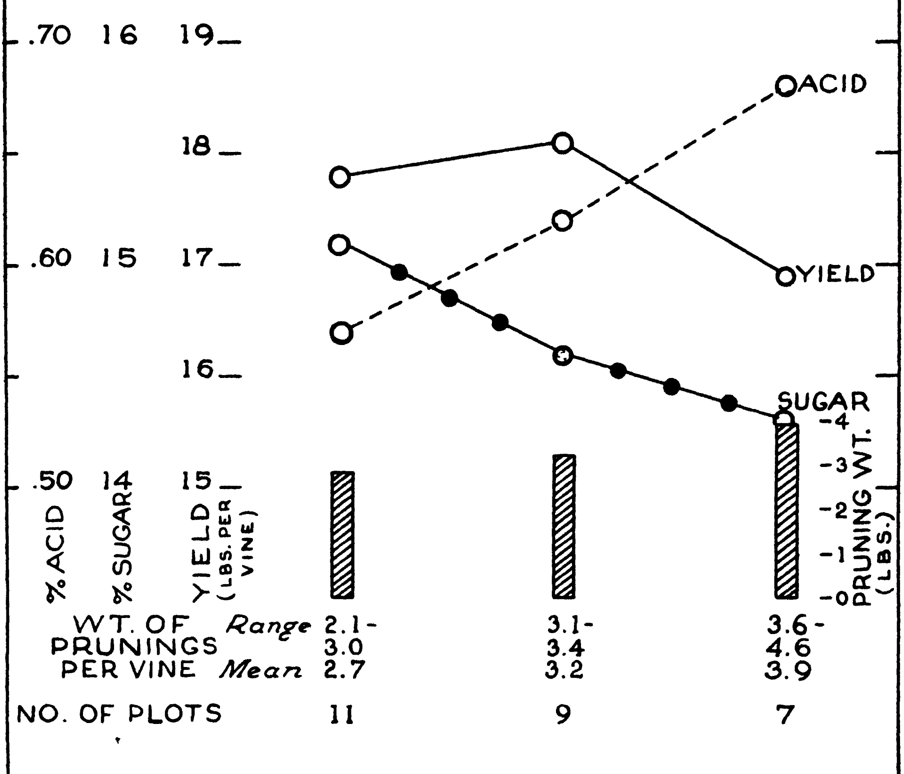
[3] Classified Vineland Clay Loam by the Department of Chemistry, Ontario Agricultural College,—moderately acid in reaction, medium in organic matter and nitrogen content, for the most part very low in readily soluble phosphorus; subsoil heavy with restricted internal drainage

FIGURE I: PRUNING WEIGHTS, YIELD, SUGAR AND ACID CONTENT OF CONCORD GRAPES ON UNTREATED PLOTS OF THE HAINES VINYARD 1932 + 1933.



*i.e.*, highest sugar and lowest acid. It must be pointed out, however, that these vines should be considered as comparatively weak growing only, as even the least vigorous plot averaged 2.1 lb. of prunings which represents very little below average vigour for the Concord variety. It is probable, though not proven as far as the authors are aware, that very weak growing vines pruned to the same numbers of buds would give fruit of inferior quality as measured by sugar and acid content. Though the very vegetative plots have fallen down in yield of fruit *they have also shown quality inferior to the less vegetative plots.* The very vegetative condition of the vines has affected the quality of the grape relatively more in acid content than in sugar content. Other data obtained by the authors have shown that in the later stages of ripening acid is reduced at a greater rate than sugar is increased.

These results indicate that growers, by overpruning *strong growing* Concord grape vines, are not only reducing the quantity but probably also the quality of the crop, or putting it another way, the very vegetative condition may result in a later ripening fruit. In the Niagara district this is an undesirable condition as it is important to hasten rather than delay the ripening of Concord. It is, of course, an easy matter for a grower to avert the strongly vegetative condition by lighter pruning, *i.e.*, leaving more buds at pruning time. Only by pruning according to the present vigour of the vine can a maximum crop of high quality fruit be obtained.

## REVUE

KOLB, J. H. et POLSON, R. A. Trends in Town-Country Relations, Research Bulletin 117, Agricultural Experiment Station, University of Wisconsin and the United States Department of Agriculture Co-operating, pp. 35.

L'étude des rapports qui existent entre la ville et la campagne est importante car elle démontre la nécessité de développer simultanément ces deux domaines. Les résultats d'une étude de ce genre conduite dans le comté de Walworth, Wisconsin, en 1929, sont présentés dans ce bulletin et comparés à ceux d'une étude semblable, faite en 1913.

Il y a eu des changements également dans sept services principaux. L'étendue desservie par les services de bibliothèque a augmenté de 158% depuis 1913. C'est l'école secondaire qui a le plus contribué à ce changement. L'étendue du pays fournissant du lait en nature a fait une augmentation nette de 64 pour cent par suite de l'amélioration des chemins, de l'emploi d'auto-camions et de la tendance à la centralisation du contrôle. L'expansion nette dans l'étendue desservie par les écoles secondaires a été de 49%. La population rurale varie de 40 à 50% du total, suivant la dimension du centre. Les services d'épiceries se sont développés de 22%. On trouve maintenant des magasins à chaîne dans tous les centres dont la population dépasse 700 personnes. Le vieux magasin général a été remplacé par un type de magasin qui ne porte que quelques lignes de marchandises. Il n'y a pas eu, en somme, d'augmentation sensible dans l'affiliation des gens de campagne avec l'église du village ou de la petite ville. Le goût des gens de campagne a changé si rapidement que les méthodes d'affaires n'ont pu être modifiées à temps pour le satisfaire. Ce sont les centres des services bancaires qui ont le moins changé; six centres ont perdu du territoire tandis que cinq en ont gagné. Les services bancaires, de même que les services d'épiceries ou d'habillements paraissent se concentrer autour de ces hommes et de ces institutions qui s'efforcent de donner un type modèle de service adapté aux résidents de leur pays, de leur village et de leur ville.

En général les familles de ferme utilisent quatre centres de service par famille, savoir, un centre à la croisée des chemins, au hameau, ou à un très petit village, un centre de deux villages ou de petite ville ou un centre de ville. On fait également des commandes par la poste. Les centres de campagne sont importants pour les services de marchandises, et pour les services primaires d'instruction et d'église. De plus en plus les petites villes et villages deviennent les centres principaux pour beaucoup des services exigés par les familles de la ferme. On peut affirmer aujourd'hui que la ville et la campagne s'unissent pour former un plus grand groupement rural. Les familles de ferme vont aux centres urbains pour les soins médicaux ou les soins d'hôpitaux, et pour se procurer de bons vêtements, et des meubles.

# RESUME DES ARTICLES PUBLIES DANS CE NUMERO

ETUDES DE NUTRITION SUR LE FRAGARIA II. UNE ETUDE DE L'EFFET DU MANQUE ET DE L'EXCES DE POTASSIUM, DE PHOSPHORE, DE MAGNESIUM, DE CALCIUM ET DE SOUFRE. M. B. Davis, H. Hill, et F. B. Johnson, Ferme expérimentale centrale, Ottawa, Canada.

Des plants de fraisiers ont été cultivés en pots, dans du sable stérile, et soumis aux traitements nutritifs que voici: mélange fertilisant complet, excès de potasse, manque de potasse, excès et manque de phosphore, excès et manque de magnésium, excès et manque de calcium, et excès et manque de soufre. On a obtenu des symptômes sur le feuillage qui pouvaient être reliés aux traitements appliqués et qui devraient être utiles dans le diagnostic. Le manque de rusticité pendant l'hiver paraît dépendre du manque de potasse plus que de tout autre traitement. Les données relatives au rendement indiquent qu'un excès de phosphore et de calcium peut nuire à la formation des boutons. La suppression complète du phosphore et du magnésium exerce un effet considérable sur la formation des boutons de fruits, tandis que la suppression complète de calcium et de soufre n'a que peu ou point d'effet. Les plantes paraissent capables d'utiliser à nouveau une proportion considérable de leur potassium original. Les analyses des tiges (feuilles et collets) pour les hydrates de carbone indiquent l'effet considérable du potassium sur l'accumulation d'hydrates de carbone. L'analyse de la matière minérale des feuilles révèle l'effet des différents traitements sur la composition des cendres et de la matière sèche. Tous les traitements par omission ont résulté en une réduction, dans la cendre et dans la matière sèche, de l'élément omis. Un antagonisme a été révélé entre le calcium et le potassium, et le phosphore et le potassium. Aucun symptôme de manque de potassium et de manque de phosphore n'a été noté sur le feuillage dans la série qui ne recevait pas de calcium, de magnésium ou de soufre, et l'on a constaté, d'autre part, une proportion élevée de ces deux éléments dans les cendres et dans la matière sèche. Des chiffres présentant les corrélations significatives suivantes sont présentés: corrélation négative entre CaO et $K_2O$ dans les cendres; corrélation positive entre MgO et $P_2O_5$; corrélation négative entre $K_2O$ et MgO, corrélation négative entre $P_2O_5$ et $K_2O$ dans les cendres.

VARIATION DE LA DIFFERENCE ENTRE LES SEXES DANS LA CROISSANCE DES POUSSINS. S. Bird et H. S. Gutteridge, Service de l'aviculture, Ferme expérimentale centrale, Ottawa, Canada.

Les données dont il est fait rapport dans cet ouvrage semblent indiquer que la différence normale entre les sexes, au point de vue de la rapidité de la croissance et de la croissance absolue, peut être sensiblement influencée par les conditions environnantes. Il a été constaté dans le groupe témoin qu'un sexe était très fortement affecté tandis que le sexe opposé, soumis à un traitement identique, ne l'était que peu ou point. Il est évident également que la réaction différente de ce sexe aurait passé inaperçue si les données avaient été traitées comme si elles venaient d'une population mélangée, et qu'elle aurait été complètement obscurcie si les facteurs de conversion avaient été employés. Les données recueillies par d'autres investigateurs indiquent une situation semblable ou inverse, et l'on en conclut donc que les données relatives à la croissance chez les volailles, mélangées ou converties, peuvent induire en erreur et ne devraient pas être employées.

RENDEMENT ET QUALITE DES FRUITS PROVENANT DE VIGNES CONCORD A FORTE VEGETATION. W. H. Upshall et J. R. VanHaarlem, Station expérimentale d'horticulture, Vineland Station, Ont., Canada.

Les résultats obtenus dans un vignoble commercial en 1932 et 1933 indiquent que les producteurs, en pratiquant un excès de taille sur des vignes Concord à forte végétation, non seulement réduisent la quantité mais abaissent probablement aussi la qualité de la récolte, parce que la maturation des fruits est retardée. C'est là un résultat déplorable dans le district de Niagara, où il est important de hâter plutôt

que de retarder la maturation des raisins Concord. Il est sans doute facile pour le producteur d'éviter cette végétation exagérée en pratiquant une taille moins rigoureuse, c'est-à-dire en laissant plus de boutons à l'époque de la taille. Que l'on se base donc, pour la quantité de taille à effectuer, sur la vigueur de la vigne; c'est le seul moyen d'obtenir une grosse récolte de fruits de haute qualité.

## CURRENT PUBLICATIONS

PEAT, MUCK AND MUD DEPOSITS. THEIR NATURE, COMPOSITION AND AGRICULTURAL USES. Frank T. Shutt and L. E. Wright, Chemistry Division, Central Experimental Farm, Ottawa. Dominion of Canada, Department of Agriculture Bulletin No. 124—New Series.

Peat and muck receive most of the space in this bulletin. There is a general description of the nature of these soils, followed by two tables giving analyses of samples from many localities. The uses and treatments of peat and muck as soil amendments, compost, and absorbent litter, and in horticulture are all discussed, while there is a valuable section on the reclamation of peat and muck lands with special reference to the work done at the Illustration Station at Caledonia Springs, Ontario. There is a short section on tidal muds, mussel and oyster shell muds, and pond, lake and river muds. This publication is a concise and practical bulletin covering the general value and use of these soils.

THE BROODING AND REARING OF CHICKS. F. L. Wood, Poultry Superintendent, New Brunswick Department of Agriculture, Fredericton, N.B. Bulletin No. 39.

This is a farmer's bulletin containing much standard information on the brooding and rearing of chicks. Particular reference is made to rations suitable to local conditions and to the work done by the New Brunswick Department in establishing pullorum-free flocks.

THE WORLD WHEAT PROBLEM AND THE LONDON AGREEMENT. Published by the Authority of the governments of the Dominion of Canada and of the Provinces of Manitoba, Saskatchewan, and Alberta.

It is not possible to summarize this publication, as it is itself a summary of some of the factors entering into the very complicated problem of wheat marketing. The pamphlet was prepared for distribution to wheat farmers in Western Canada. It sets out clearly and distinctly the problem of increased carry-over and asks for support and co-operation in carrying out whatever measures may be evolved to prevent an increase in total production and make possible a decrease in carry-over. It does not attempt to outline the steps to be taken to carry out Canadian obligations under the Wheat Agreement, but it is a useful and convenient publication from which to quickly get a comprehensive view of the general problem itself. Copies are available from the governments concerned.

JOHNE'S DISEASE OF CATTLE. G. Hilton, Veterinary Director General, Health of Animals Branch, Ottawa. Dominion of Canada, Department of Agriculture Bulletin No. 167—New Series.

The introduction to this bulletin states that "Although this disease is not prevalent in Canada, this pamphlet has been prepared with a view to giving cattle breeders and owners the available information to assist them to recognize or suspect it when it does occur, and so enable them to guard their interests by taking prompt measures to control the disease, and to prevent its spread. Much depends upon the alertness of the live stock owner in detecting disease, his promptitude in isolating affected animals and reporting to the authorities, as to whether the infection is quickly controlled or a serious outbreak develops."

There is no known cure for Johne's disease after symptoms develop and no available system of immunization. Treatment must be restricted to preventive measures. This disease has not been brought under the provisions of the Animal Contagious Diseases Act, but the Health of Animals Branch is prepared to render assistance in identifying infection. A description is given of the symptoms, and control measures are outlined

# THE ECONOMIC ANNALIST

A REVIEW OF AGRICULTURAL BUSINESS PREPARED QUARTERLY BY THE AGRICULTURAL ECONOMICS BRANCH, DEPARTMENT OF AGRICULTURE, OTTAWA

Vol. IV, No. 1. March, 1934

## THE ECONOMIC SITUATION

PREPARED IN THE AGRICULTURAL ECONOMICS BRANCH, DEPARTMENT OF AGRICULTURE, OTTAWA, FROM BASIC DATA COLLECTED BY THE DOMINION BUREAU OF STATISTICS

The index number of wholesale prices in Canada showed a substantial gain in February, being 1.5 points above the index for January. The sub-indexes for vegetable products, animals and their products, fibres, textiles and textile products, wood, wood products and paper, iron and its products, advanced; non-ferrous metals and their products, and non-metallic minerals and their products declined, while chemicals and allied products remained unchanged.

*Retail Prices.*—The index number of retail prices and costs of services advanced from 78.7 in January to 79.2 in February. Increased prices of food products were entirely responsible for the rise in the index number. February was the fifth consecutive month in which an advance in retail prices has been registered.

*Employment.*—The adjusted index of employment advanced from 96.5 at the first of February to 97.4 as at the first of March. Employment is, therefore, being more than maintained. It is of special significance that considerable improvement took place in manufacturing industries.

*Physical Volume of Business.*—The physical volume of business receded fractionally in March. The index for February was 86 4 as compared with 86 8 in January. Industrial production was also a little lower, declining from 84.5 to 84.0. Mineral production fell from 120 6 to 117 2. Output of copper and nickel was lower but lead, zinc, and silver production was higher. There was little change in output of gold.

The index of manufacturing registered a substantial gain from 80.7 in January to 83.2 in February. Advances in milling, lumbering, textile imports, and automobile construction were the chief factors contributing to the improvement. The index of iron and steel production was lower because of recessions in pig iron, steel production, and imports of iron and steel. Construction continued at low levels, being even lower than in January. There is still prospect for improvement in this industry when spring opens up.

*Agricultural Products.*—Wholesale prices of Canadian farm products advanced from 55.3 in January to 58.0 in February. This was largely due to improvement in prices of animal products, this index rising from 67.8 to 72.5. While the advances were not uniform practically all classes of stock sold at higher prices Supplies of eggs fell off sharply and prices therefore rose rapidly. Butter prices were also higher.

Agricultural marketings were much higher in February, the total index being 67.1 as compared with 48.2. Animal marketings rose from 77.6 to 94.0 while those of grain were 61.1 as against 41.6 in January. The movement of wheat was not much higher than in the previous month but that of oats and barley was much larger. Shipments of flax were about the same as in January, while rye moved in slightly larger volume.

*Cold Storage Holdings.*—The index of cold storage holdings fell to 98.6 at the first of February and a further depletion of stocks has resulted in a decline in the index to 97.0 at the first of March. It will be noted that these indexes are below

ANNUAL AND MONTHLY INDEX NUMBERS OF PRICES AND PRODUCTION COMPUTED BY DOMINION BUREAU OF STATISTICS

| Year | Wholesale Prices 1926 = 100 | | | | Retail prices and cost of services (5) | Production (6) 1926 = 100 | | | |
|---|---|---|---|---|---|---|---|---|---|
| | All commodities (1) | Farm products (2) | Field products (3) | Animal products (4) | | Physical volume of business | Industrial production | Agricultural marketings | Cold Storage holdings |
| 1913 | 64.0 | 62.6 | 56.4 | 77.0 | 65.4 | | | | |
| 1914 | 65.5 | 69.2 | 64.9 | 79.0 | 66.0 | | | | |
| 1915 | 70.4 | 77.7 | 76.9 | 79.2 | 67.3 | | | | |
| 1916 | 84.3 | 89.7 | 88.4 | 92.3 | 72.5 | | | | |
| 1917 | 114.3 | 130.0 | 134.3 | 119.6 | 85.6 | | | | |
| 1918 | 127.4 | 132.9 | 132.0 | 134.7 | 97.4 | | | | |
| 1919 | 134.0 | 145.5 | 142.4 | 152.5 | 107.2 | 71.3 | 65.5 | 48.1 | 47.1 |
| 1920 | 155.9 | 161.6 | 166.5 | 149.9 | 124.2 | 75.0 | 69.9 | 52.6 | 94.2 |
| 1921 | 110.0 | 102.8 | 100.3 | 108.5 | 109.2 | 66.5 | 60.4 | 65.2 | 86.4 |
| 1922 | 97.3 | 86.7 | 81.3 | 99.1 | 100.0 | 79.1 | 76.9 | 82.6 | 82.8 |
| 1923 | 98.0 | 79.8 | 73.3 | 95.1 | 100.0 | 85.5 | 83.8 | 91.4 | 87.6 |
| 1924 | 99.4 | 87.0 | 82.6 | 97.2 | 98.0 | 84.6 | 82.4 | 102.5 | 114.9 |
| 1925 | 102.6 | 100.4 | 98.1 | 105.7 | 99.3 | 90.9 | 89.7 | 97.2 | 108.6 |
| 1926 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.9 | 100.0 |
| 1927 | 97.7 | 102.1 | 99.9 | 105.7 | 98.4 | 106.1 | 105.6 | 103.6 | 110.0 |
| 1928 | 96.4 | 100.7 | 92.6 | 114.3 | 98.9 | 117.3 | 117.8 | 146.7 | 112.8 |
| 1929 | 95.6 | 100.8 | 93.8 | 112.5 | 99.9 | 125.5 | 127.4 | 101.1 | 109.6 |
| 1930 | 86.6 | 82.3 | 70.0 | 102.9 | 99.2 | 109.5 | 108.0 | 103.0 | 128.4 |
| 1931 | 72.2 | 56.3 | 43.6 | 77.6 | 89.6 | 93.5 | 90.4 | 99.0 | 125.7 |
| 1932 | 66.7 | 48.4 | 41.1 | 60.7 | 81.4 | 78.7 | 74.0 | 114.3 | 120.1 |
| 1933 | | | | | | | | | |
| Jan. | 63.0 | 43.6 | 35.1 | 57.9 | 79.1 | 68.1 | 62.2 | 56.1 | 112.0 |
| Feb. | 63.6 | 43.0 | 36.0 | 54.7 | 78.4 | 67.0 | 60.0 | 76.5 | 127.6 |
| Mar. | 64.4 | 44.7 | 38.0 | 56.0 | 77.8 | 68.4 | 62.5 | 129.0 | 135.8 |
| April | 65.4 | 46.8 | 41.1 | 56.4 | 78.1 | 69.8 | 65.1 | 104.1 | 112.7 |
| May | 66.9 | 51.2 | 46.9 | 58.4 | 77.0 | 76.4 | 72.7 | 95.4 | 110.4 |
| June | 67.6 | 52.6 | 49.4 | 57.9 | 77.0 | 82.2 | 79.8 | 221.9 | 119.9 |
| July | 70.5 | 60.1 | 60.8 | 59.0 | 77.2 | 84.1 | 82.6 | 221.9 | 119.9 |
| Aug. | 69.4 | 57.0 | 54.9 | 60.5 | 78.6 | 89.8 | 89.5 | 197.2 | 114.2 |
| Sept. | 68.9 | 54.7 | 49.5 | 63.4 | 78.8 | 90.8 | 90.2 | 101.1 | 115.7 |
| Oct. | 67.9 | 51.4 | 44.6 | 62.8 | 77.9 | 88.2 | 87.4 | 70.5 | 112.7 |
| Nov. | 68.7 | 53.8 | 46.7 | 65.8 | 78.1 | 85.5 | 83.9 | 41.8 | 111.1 |
| Dec. | 69.0 | 53.3 | 45.3 | 66.6 | 78.4 | 86.2 | 85.1 | 30.7 | 107.6 |
| 1934 | | | | | | | | | |
| Jan. | 70.6 | 55.3 | 47.9 | 67.8 | 78.7 | 86.8 | 84.5 | 48.2 | 108.1 |
| Feb. | 72.1 | 58.0 | 49.3 | 72.5 | 79.2 | 86.4 | 84.0 | 67.1 | 98.6 |

1. See Prices and Price Indexes 1913-1928, pp. 19-21, 270-289 and 1913-1931, p. 15.

2. Wholesale prices of Canadian products of farm origin only. See Prices and Price Indexes 1913-1931, p. 33, and Monthly Mimeographs 1932 and 1933.

3. Wholesale prices of grains, fruits and vegetables.

4. Wholesale prices of Animals and Animal Products.

5. Including foods, rents, fuel, clothing and sundries, See Prices and Price Indexes 1913-1928, pp. 181-185, 290-293. 1926=100.

Prices and Price Indexes 1913-1931, p. 122, and Monthly Mimeographs 1932-1933.

6. Monthly Review of Business Statistics, p. 8, and Monthly Indexes of the Physical Volume of Business in Canada, supplement to the Monthly Review of Business Statistics, November, 1932.

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the base period of 1926 and this indicates a decided improvement in the rate at which food products are being moved into consumption.

*Marketing Policies.*—Interest in revision of marketing policies continues. More schemes are being prepared in the United Kingdom. New Federal and State Legislation has been introduced in Australia. The United States program is being pushed ahead vigorously. The Honourable Robert Weir has given notice of his intention to introduce legislation to improve the marketing of agricultural products in Canada. The immediate cause of the dissatisfaction with marketing services is, of course, to be found in the low prices of agricultural products which prevailed between 1920 and 1924 and since 1929. This situation has given rise to the feeling that improvement in marketing is not only desirable but imperative. While these "short time causes" are of great importance, the changes in agricultural production, in the technique of agriculture, the distribution of population, the transport of food products, together with the improvements in marketing methods which have taken place during the last half century or more are not to be overlooked. New areas of production have been opened up. Products now reach export markets in quantities hitherto regarded as impossible of achievement. These factors have exerted an influence on both foreign and domestic markets and the organization of industry.

The tendency towards concentration of business in larger units suggests the need of a greater degree of governmental control, for while economies can undoubtedly be effected through large scale operations, the additional strength gained through the organization of big business calls for the establishment of metes and bounds in industrial relations.

The tendency towards further governmental support in marketing at present has undoubtedly been influenced by the war-time policies of purchasing and distributing products under Boards set up by governments for specific purposes. In the minds of those who have experienced difficulties in marketing, the operation of these Boards have often been associated with high prices and for the most part honesty and efficiency. Therefore, while present proposals are not modelled after the war time Control Boards, the influence of such organizations cannot be overlooked.

Having experienced low prices for a period of years farmers now seek a means of co-ordination of marketing services in such a way that more effective distribution can be secured, and for the most part seek legislation which will enable them to secure such a form of organization as will bring this about. Such plans are frequently supported, moreover, even by those who might otherwise be opposed because of the pressure of international competition which focuses attention on the policies adopted in other countries and the ways and means of holding old markets and developing new outlets wherever possible.

The present may be regarded as an experimental stage, but despite this, the tendency in the future is likely to be in the direction of more regulation rather than less.

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The following news item concerning imports of dairy products to Great Britain was taken from British newspaper reports. "Unable to deal satisfactorily with the condition of the butter and cheese markets by regulation of imports, the Government has felt obliged to come to the assistance of the dairying industry by guaranteeing minimum prices for butter and cheese for the two years beginning April 1 next". Supplies of dairy products from the Dominions have been on the increase to the British market and moreover they show no sign to diminish in quantity. Cheese and butter from the Dominions enter free of duty under the Ottawa agreements so the British farmer had little to gain in raising the import duty on foreign products. The Dominions have shown little inclination to accept the view that restriction of shipments of either butter or cheese to the British market is in their own interests. The Governments' alternative, therefore, is to subsidize the British farmer in the production of these products. Though the Government has decided against restrictions on the imports of butter and cheese, it has taken action in regard to other milk products, the imports of which have been subject to regulation since the middle of last year. The Dominions were asked to restrict imports of condensed, whole and skim milk, milk powder and cream from June to December, 1933, to the same level as in the corresponding period in 1932. The principal foreign countries, namely, the Netherlands and Denmark, were asked to limit their exports during this period to 80% of the quantities sent in the last seven months of 1932, with the exception of December when the proportion was raised to 85%.

# THE COST OF MANUFACTURING CHEESE IN QUEBEC

J. F. Booth[1] and C. V. Parker[2]

An article on the cost of producing cheese in Ontario was presented in a previous issue of this periodical[3]. In this article a similar review is given of the costs of operating 120 cheese factories situated in the counties of Lac St. Jean, Chicoutimi, Beauce, Arthabasca, Yamaska, Megantic, and Wolfe in the Province of Quebec.

The development of the cheese industry in Quebec has been very similar to that of Ontario. Between 1864, when the first cheese factory was established in Ontario, and 1870, several factories were built in the county of Missisquoi, Quebec. A rapid development in factory building and production took place until 1900-04. In 1900, production of factory cheese was 80,630,999 pounds. Since 1904, however, a decline in production has taken place. The total output in 1931 amounted to 25,907,691 pounds. Despite this rapid decline cheese production is still a major industry in the province and demands recognition in any program of research designed to improve dairying as a whole.

The problems confronting the cheese industry in Quebec are also quite similar to those of Ontario. In both provinces declining volume of output has had a tendency to raise production costs per unit of product manufactured.

The effect has been somewhat greater in Quebec, however, because factories there are considerably smaller than in Ontario. The average production per factory in Quebec in 1931 was 23 3 tons while in Ontario it was 81.47 tons, according to the data collected in the survey.

*Costs of Manufacturing Cheese.*—Costs of production are presented in the accompanying tables according to two methods of calculation. In method I the actual rates paid by the patrons to have their milk converted into cheese have been taken. These rates represent the charges which private owners of factories levied and the set deductions which patron-owned concerns made from the sale value of the cheese in 1931. In addition, patron organization costs, which include salaries of officials, milk testing and stationery, have been added to the rates charged by private owners. Method I then deals with costs as the patrons think of them.

The cost of operation based on actual charges to patrons as described under method I is presented in Table 1. Factories were classified according to the pounds of cheese produced. The costs for the smallest group, producing under 40,000 pounds averaged 1.86 cents per pound. For the largest factories, 80,000 pounds and over,

TABLE 1.—RELATIVE COSTS OF MANUFACTURING CHEESE AS INDICATED BY TWO METHODS OF CALCULATION

| Size of factory (Pounds of cheese) | Method I. Actual rates charged | | Method II. Costs, including interest and depreciation at established rates | | Difference between two methods |
|---|---|---|---|---|---|
| | No. of factories | Cost per pound (cents) | No. of factories | Cost per pound (cents) | (cents) |
| Under 40,000 | 46[1] | 1.86 | 47 | 3.02 | 1.16 |
| 40,000 - 59,999 | 53 | 1.85 | 53 | 2.49 | 0.64 |
| 60,000 - 79,999 | 9 | 1.78 | 9 | 2.04 | 0.26 |
| 80,000 and over | 11 | 1.83 | 11 | 2.18 | 0.35 |
| Total or average | 119 | 1.84 | 120 | 2.52 | 0.68 |

[1] One factory omitted—no actual rate charged.

NOTE.—Average expense per factory: Method I, $858.53: Method II, $1,174.37.

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[1] Commissioner, Agricultural Economics Branch, Ottawa.

[2] Field Assistant, Agricultural Economics Branch, Ottawa.

[3] See The Economic Annalist, Vol. III, Nos. 10, 11, 12, pp. 99–102, and Scientific Agriculture, No. 15, pp. 269–272.

costs were 1.83 cents per pound. The average expense for all factories was $858.53 per factory or 1.84 cents per pound of cheese.

It was found on examining the costs as given by method I that all charges were not fully met. Factory owners and managers of patron concerns did not make adequate allowance for depreciation and interest in arriving at the rates to be charged for cheese production. Slightly more than half of the Quebec factory owners were charging 15% of the value of the product made. In 1931, when cheese was selling at around 11 cents, the receipts to these makers only averaged 1.60 to 1.70 cents per pound whereas when cheese prices were higher they were receiving from 2 to 3 cents per pound. Consequently eleven of the 100 owner-makers actually had cash deficits while the majority did not receive sufficient to cover cash costs, interest, depreciation and a living wage. The other owner-makers were charging from 1¾ to 2¼ cents per pound, but though they were receiving more than those who worked on a percentage basis, they too were unable to meet all the expenses incurred when depreciation and interest costs were adequately provided for. The same may be said of the 20 factories which were owned by the patrons; in many cases patrons actually lost part of their capital in 1931 by not adequately covering depreciation.

The general practice in cheese factory operation is to meet replacement costs as they occur, but owing to the retrenchment which was taking place in 1931 many factory owners probably spent less than usual on capital items. It was found that expenditures to meet depreciation (*i.e.*, new equipment for replacement purposes and reconstruction of buildings) was $6,156.00 for the 120 factories which amounted to only 30 8% of the estimated depreciation for the year of the study. The amounts spent on some factories were greater than for others and of course rates of depreciation do vary in different factories. In order, however, to place all concerns on the same basis and also to take into consideration all the costs incurred in factory operation, method II was adopted.

The costs as listed under method II, Table 1, are made up of the following charges: (1) the actual cash operating expenses (excluding sums spent on capital items and wages to makers); (2) interest on capital invested at 5%, depreciation on frame buildings at 5% and on brick or stone structures at 3% of the present value, and depreciation on equipment calculated on the "years future use" basis; present values and years future use were obtained for the major items of equipment; by dividing the years into the present value a depreciation figure for the year of the study was obtained; (3) makers' salaries taken from estimates derived from makers and also by deducting their expenses from the amounts they received.

TABLE 2.—RANGE OF COSTS PER POUND FOR MANUFACTURING CHEESE

| Costs (cents per lb.) | Number in class | Weighted average | Per cent of total | Costs (cents per lb.) | Number in class | Weighted average | Per cent of total |
|---|---|---|---|---|---|---|---|
| 1.5 - 1.99[1] | 17 | 1.84 | 14.2 | 4.0 - 4.49 | 5 | 4.27 | 4.2 |
| 2.0 - 2.49 | 47 | 2.27 | 39.2 | 4.5 - 4.99 | 1 | 4.83 | 0.8 |
| 2.5 - 2.99 | 24 | 2.75 | 20.0 | 5 + | 1 | 5.58 | 0.8 |
| 3.0 - 3.49 | 17 | 3.26 | 14.2 | | | | |
| 3.5 - 3.99 | 8 | 3.63 | 6.7 | Total or average | 120 | 2.52 | 100.0 |

[1] The lowest cost was 1.68 cents per pound.

Turning to Table 1 again it can be seen that the average cost per pound for manufacturing cheese was 2 52 cents when all charges were taken into account (method II). The data reveal a wide difference in cost between actual rates charged and cost of operation including interest and depreciation in the first two groups of factories. It would appear that a rate ranging from 2.5 to 3 cents per pound would have to be charged when production per factory was less than 60,000 pounds in order that all expenses might be met. In the larger factories total charges were more nearly in line with actual rates received than in the smaller units. In the last two groups of factories a rate of 2–2½ cents per pound would be sufficient to cover all costs.

*The Effect of Volume on Costs.*—Besides portraying the difference in costs between methods I and II, Table 1 also shows the effect of volume on costs of production. Factories in which production was less than 40,000 pounds had a cost of 3.02 cents per pound when all items of expense were included while the rate in the largest concerns was 2.18 cents, a difference of 0.84 cents per pound. One of the 11 factories in this larger group, however, had exceptionally high costs, and when it was excluded the other 10 averaged 2.03 cents. Thus, the trend in costs from small to large groups was definitely downwards.

An analysis of the individual items of expense, the data for which are not included in this article, showed that decreases in interest, depreciation and labour costs per unit of product were chiefly responsible for the reduction in cost of manufacture as volume of production increased.

In Table 2 the influence of volume of production is also shown. It was found that the extreme range in costs was from 1.68 to 5 58 cents per pound, a difference of 3.90 cents. The 5.58 cent rate was for the smallest factory while the 1 68 cent figure was for one of the larger plants.

TABLE 3.—COMPARISON OF COST PER POUND OF CHEESE OF MAIN ITEMS OF EXPENSE BY AREAS

| Main items of expense | Cost per pound of cheese (cents per pound) | | | |
|---|---|---|---|---|
| | Combined area 120 factories | Northern area 60 factories | Southern area 60 factories | Difference Northern over Southern |
| Boxes | .277 | .322 | .232 | .090 |
| Supplies | .255 | .293 | .218 | .075 |
| Fuel | .200 | .245 | .156 | .089 |
| Taxes and insurance | .105 | .154 | .055 | .099 |
| Organization salaries | .043 | .044 | .042 | .002 |
| Hired labour and board | .080 | .092 | .068 | .024 |
| Maker's salary | .861 | .825 | .897 | −.072 |
| Other factory expense | .037 | .048 | .026 | .022 |
| Repairs | .048 | .060 | .036 | .024 |
| Interest | .257 | .318 | .196 | .122 |
| Depreciation | .358 | .444 | .272 | .172 |
| Total expense | 2 521 | 2.845 | 2 198 | .647 |

*Cost of Production by Areas.*—Manufacturing costs varied considerably between the northern and southern area of Quebec. The northern area comprises Lac St. Jean and Chicoutimi Counties and is represented in this study by 60 factories, while the cheese producing area south of the St. Lawrence (the southern area) is also represented by 60 factories. In Table 3, the costs for the main items of expense, together with the total expense per pound of cheese, are listed for each of the districts and for the combined area. The total expense averaged 2.845 cents per pound in the north and 2.20 cents in the south. Every item of expense except that of makers' salary was found to be considerably higher in the northern area than it was in the southern area. The higher costs for boxes, supplies, fuel and repairs were due to the distance of northern factories from distributing centres for these items. A recently constructed water system or aqueduct was responsible for the higher taxation in the north. Interest and depreciation were greater because average factory valuations in the north were $900 higher than in the south. In all, the difference in cost of manufacturing between the two areas averaged 0.647 cents per pound of cheese, or $300 per factory, despite the fact that there was only 50 pounds difference in average production of cheese per factory as between the two areas.

*Summary and Conclusions.*—Cheese factory production in the province of Quebec has been declining since the early years of the present century. Decreased volume of production in factories which even under more favourable conditions had small turnovers, is resulting in high cost of production per unit of product. In seeking a solution to this problem the suggestion has frequently been made that cheese factory districts should be consolidated and many of the factories closed. It may be said that the difference in costs incurred by factories included in this study is not large enough to warrant a strong case being made for factory consolidation. It should be noted, however, that the real possibilities in this connection cannot be demonstrated in factories of this size. In order to obtain minimum costs the production per factory should be very much larger than any included in this study.

The data obtained, however, indicate that a considerable saving can be made in costs by having a greater volume per factory. This is achieved by making maximum use of labour, plant and equipment. In many cases greater volume could be obtained by the amalgamation of factory districts and by the closing of unnecessary factories. This, in turn, would mean longer hauls for patrons or the organization of milk routes.

There were no milk routes in connection with any of the 120 factories studied in Quebec as practically all the patrons lived within two miles of a factory. Route hauling, therefore, would be a complete change from the present system. The type and condition of roads as well as costs would have to be considered before patrons decided to make this change.

An alternative to consolidation as a means to lowering costs would be an endeavour to increase volume of output per factory by other methods. This might be done by increasing the number of patrons per factory or by adding to the volume of milk delivered by each patron. At present there is an average of 20 patrons per factory in Quebec who, as a rule, have about 9 or 10 cows. Factories operate nearly 6 months in the year and in this period an average of 2,438 pounds of milk per cow is delivered. Much could be done to increase volume of cheese production by lengthening the period of factory operation and by increasing the production per cow.

The present charges for cheese manufacture will have to be raised if many of the factory owners are to remain in business. This is particularly true in cases where the rate charged is set as a percentage of the value of cheese produced. The alternative to higher charges per pound of cheese manufactured is larger volume of production per factory.

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According to British newspaper reports an agreement has been reached between the Pigs and Bacon Marketing Boards in regard to the contracts for bacon pigs for the 10-month period commencing March. The price has already been fixed for the first two months at 12s. 6d. per score for a basic pig in Class 1. This price will be subject to a levy of 6d. per score to repay the co-operative loan which was advanced to cover curers' losses in the last contract period. For the following eight months the price will be based on the cost of producing the pig, the cost of curing it into bacon, and the selling price of bacon. In this way the producer will share in the whole process.

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The Canadian Federation of Dairy Farmers was organized at Ottawa on March 15th. A. H. Mercer, Fraser Valley Milk Producers' Association, Vancouver, was elected president. J. F. Desmarais, Co-operative Fédérée de Quebec, and W. A. Amos, United Farmers' Co-operative Company, Toronto, were elected vice-presidents, and H. B. Cowan of Peterborough was appointed secretary-treasurer.

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Press reports state that Dr. Wm. Allen, who was appointed a Royal Commissioner to inquire into the marketing of milk in Saskatchewan has recommended that a plan of control similar to that inaugurated under the Manitoba Public Utilities Commission in 1932 and adopted in Alberta in 1933 be inaugurated in Saskatchewan. The report, it is understood, will be the basis of legislation to be introduced at the present session of the Legislature.

# BUSINESS ANALYSIS OF THE OPERATIONS OF TEN CO-OPERATIVE FRUIT COMPANIES IN NOVA SCOTIA[1]

A. E. RICHARDS[2]

Returns are received by the Agricultural Economics Branch annually on a voluntary basis from farmers' business organizations throughout Canada. These are grouped provincially under commodity headings, and the business operations of certain groups are analysed on a comparable basis in order to bring out strong and weak points in the organization of individual companies.

In 1932, for Canada as a whole, returns were received from 110 co-operative companies handling fruit. These companies reported combined shareholders and members numbering 8,232 who contributed to a total business of $7,679,713. The Nova Scotia returns for the same year were received from 44 companies with a membership of 1,086 who reported $1,487,209 of business.

The combined and comparative balance sheets and operating statements of ten Nova Scotia fruit companies are shown in Tables 1 and 2 for the year ending May 31, 1931. Returns for that period are used in this analysis as they were more complete than for the year 1932.

The season 1930-31 and the two or three years preceding brought unusual difficulties for the fruit grower in a disorganized export market and low prices. In order to tide the grower over what was looked upon as a temporarily bad situation, and to hold his patronage, companies sold their feed and supplies on credit. This in turn led to borrowings on the part of the companies which resulted in heavy indebtedness and high interest charges. To meet competition or satisfy patrons, operating margins were narrowed to a point where some companies were not covering overhead. This situation is reflected in the financial statements of the companies in Tables 1 and 2.

*Assets.*—Accounts and notes receivable under current assets amount to $141,191.36 (Table 1). For most companies this figure indicates a liberal credit policy which once instituted is difficult to overcome. It results in a heavy load for the companies to carry, for on the other side of the balance sheet under current liabilities, we find an equivalent sum for accounts payable. Merchandise inventory is a sizeable item due to the fact that nearly half of the business of these fruit companies is derived from the sale of merchandise and supplies. With the fiscal year closing in the spring of the year, stocks of fertilizer and other supplies are probably higher than in some other seasons when the balance sheet items would show quite a different relation to one another.

The combined value of plant and equipment, including real estate, totals $161,010.22 or 41 7% of total assets. The ratio of business to plant value (Table 3) for all companies is 3.14 to 1 which means that on the average the companies did $3.14 of business for each $1.00 plant value. Some companies show a higher ratio, which usually means a more intensive use of plant and equipment, and this in turn is associated with a proportionally lower overhead.

*Debt and Net Worth.*—Accounts payable is a large item amounting to $143,386.90 or 37.2% of all liabilities and net worth. Bank loans appear unduly large also, amounting to $63,038.88 which is 16.3% of all liabilities and net worth. Along with other current liabilities the total assumes larger proportions than is generally considered desirable. The ratio current assets to current liabilities brings out the situation more clearly but less encouragingly. Table 3 shows the ratio for all companies which stands 0.91 to 1 and means that all companies combined have 91 cents of readily convertible assets for each $1.00 of current indebtedness. Company K shows a comparatively strong position in this regard but other companies are considerably below what is considered the standard for many types of business.

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[1] This article deals with a section of a report on farmers' business organizations in Canada awaiting publication by the Agricultural Economics Branch.

[2] Agricultural Economist, Department of Agriculture, Canada.

TABLE 1.—COMPARATIVE BALANCE SHEETS OF TEN CO-OPERATIVE FRUIT COMPANIES IN NOVA SCOTIA AS AT MAY 31, 1931*

| | Total all companies | | K | L | M | N | O | P | Q | R | S | T |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $ | % | % | % | % | % | % | % | % | % | % | % |
| Cash on hand and in bank | 5,077.55 | 1.3 | 4.3 | 0.4 | 2.4 | — | — | 3.0 | 4.4 | 0.5 | 0.9 | 0.9 |
| Accounts and notes receivable | 141,191.36 | 36.6 | 31.4 | 36.5 | 47.2 | 20.4 | 22.5 | 15.5 | 44.4 | 32.2 | 70.1 | 31.5 |
| Merchandise inventory | 66,491.73 | 17.3 | 17.8 | 1.9 | 9.6 | 30.1 | 24.0 | 30.3 | 19.7 | 35.3 | 5.9 | 11.8 |
| Other | 2,643.18 | 0.7 | 0.9 | 1.4 | 1.3 | — | — | 1.1 | 0.3 | 0.9 | — | 0.3 |
| Total current assets | 215,403.82 | 55.9 | 54.4 | 40.2 | 60.5 | 50.5 | 46.5 | 49.9 | 68.8 | 68.9 | 76.9 | 44.5 |
| Plant, less depreciation | 161,010.22 | 41.7 | 43.4 | 58.5 | 30.1 | 46.4 | 47.0 | 46.8 | 28.8 | 30.1 | 21.8 | 52.6 |
| Other | 9,200.00 | 2.4 | 2.2 | 1.3 | 9.4 | 3.1 | 6.5 | 3.3 | 2.4 | 1.0 | 1.3 | 2.9 |
| Total fixed assets | 170,210.22 | 44.1 | 45.6 | 59.8 | 39.5 | 49.5 | 53.5 | 50.1 | 31.2 | 31.1 | 23.1 | 55.5 |
| Total assets | 385,614.04 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| LIABILITIES AND NET WORTH | | | | | | | | | | | | |
| Accounts payable | 143,386.90 | 37.2 | 23.8 | 49.2 | 38.3 | 40.8 | 36.0 | 20.3 | 30.5 | 28.7 | 102.5 | 18.2 |
| Bank loans | 63,038.88 | 16.3 | — | 3.9 | 8.8 | 46.8 | 37.3 | 23.7 | 17.8 | 24.2 | — | 20.9 |
| Accrued expenses | 2,911.97 | 0.8 | 1.0 | 0.6 | 0.4 | 1.5 | 1.8 | 0.3 | 1.0 | 0.6 | 0.1 | 1.0 |
| Other | 28,055.00 | 7.3 | — | 1.0 | 12.8 | — | — | — | — | 9.8 | — | 19.0 |
| Total current liabilities | 237,392.75 | 61.6 | 24.8 | 54.7 | 60.3 | 89.1 | 75.1 | 44.3 | 49.3 | 63.3 | 102.6 | 59.1 |
| Mortgages | 33,500.00 | 8.7 | 26.9 | 17.7 | — | — | — | 10.2 | 14.9 | 7.4 | — | 3.9 |
| Total fixed liabilities | 33,500.00 | 8.7 | 26.9 | 17.7 | — | — | — | 10.2 | 14.9 | 7.4 | — | 3.9 |
| Capital stock | 90,293.10 | 23.4 | 28.9 | 24.4 | 33.7 | 15.9 | 18.4 | 14.6 | 20.2 | 22.6 | 8.6 | 30.4 |
| Reserve for contingencies | 4,791.32 | 1.2 | — | — | 3.2 | — | — | 16.8 | 3.1 | — | 2.0 | — |
| Other | 21,025.55 | 5.5 | 5.4 | 13.0 | 2.7 | — | 0.6 | 7.5 | 2.2 | 1.8 | 4.4 | 6.7 |
| Surplus | −1,388.68 | −0.4 | 14.0 | −9.8 | 0.1 | −5.0 | 5.9 | 6.6 | 10.3 | 4.9 | −17.6 | −0.1 |
| Total net worth | 114,721.29 | 29.7 | 48.3 | 27.6 | 39.7 | 10.9 | 24.9 | 45.5 | 35.8 | 29.3 | − 2.6 | 37.0 |
| Total liabilities and net worth | 385,614.04 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

* Individual plants are designated by letters K, L, M, etc.

Along with mortgages of $33,500.00 for all companies total debt to outside interests amounts to $270,892.75 which is greatly in excess of owned capital represented in the net worth. The ratio of worth to debt brings out the real position, which for all companies is .42 to 1 or, in other words, for every 42 cents contributed and held in the name of the members outside creditors have $1.00 invested and expect to be paid back in full, with interest. No company among the ten shows an excess of worth and for some the position is far from satisfactory.

Working capital is the difference between current assets and current liabilities. For the companies combined this is a minus quantity and is suggestive of financial difficulties. Five companies show a small working capital of less than 1% of total assets.

A number of companies are without reserves and on the year's operations failed to provide a surplus. For the companies as a whole there is a debit balance of $1,388.68 although six out of the ten show a surplus.

*The Operating Statement.*—Total business amounted to $506,358.08. Farm products, which consisted almost entirely of apples, sold for $261,412.61. This made up 51 6% of the business. Producers were paid $247,658.43 or 94.73% of the sales price. This is equivalent to an operating margin of slightly over 5%; such a narrow spread, of necessity, means that no reserves could be built up with which to reduce indebtedness. Merchandise and supplies with a sales value of $242,009.52 accounted for 47.8% of the total business. The cost of this merchandise was $226,571.68 which gave a spread of 6.8% to cover handling costs.

An average operating margin of only 5% on fruit sales and 7% on merchandise means that some of the companies are turning back everything to the grower of fruit and providing supplies at cost or less than cost. A company has no chance to establish a sound business structure following such a policy and only a business without creditors and with ample reserves can afford to follow such a course and survive. Members of a co-operative fruit company must realize that the warehouse is as much a part of their property and business as the orchard and requires just as fair treatment and business-like handling.

In the items of expense the charge for wages and salaries was $11,027.61, which amounts to 2 2% of total business. Interest on borrowed money, the other large item, totals $8,427.06 or 1.7% of the total volume of business. Insurance and taxes combined are less than one-half of one per cent. In relation to total expenses wages and salaries use 34 3% and interest 26.2%. For three companies interest was the largest item of expense and exceeded 30%. Total expenses for all companies amounted to 5 8% of total business with individual companies ranging from 3 to 13%. The net operating income or net profit for all companies was $2,970.03. To this was added other income of $23,465.52 which, for many companies, was unapportioned surplus carried forward from the previous year. A small part of the net income for distribution was paid out in dividends but the greater portion was again carried into the next year as undivided income. No allowance was made for patronage refund and nothing was carried to reserve.

*Constructive Financial Policy Necessary.*—This analysis indicates the need of a definite and constructive financial policy. If, for example, the financial statements of these ten fruit warehouses as shown in Tables 1 and 2 could be considered as representing one large company and if the patrons would agree to stand together and ignore competitors who might offer small immediate gains, in five years the combined statement would present a very different picture.

If the patrons of the company would agree to permit the warehouse to increase its margin by 5% on fruit sales and by 2% on merchandise sales they would still be operating on a comparatively small margin. In other words, they would agree to accept 90 cents of the sales dollar from fruit in place of 95 cents and allow a margin

TABLE 2.—COMPARATIVE OPERATING STATEMENTS OF TEN CO-OPERATIVE FRUIT COMPANIES IN NOVA SCOTIA FOR THE YEAR ENDING MAY 31, 1931*

| | Total all companies | | | K | | L | | M | | N | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | $ | % of total business | % of gross margin | % of total business | % of gross margin | % of total business | % of gross margin | % of total business | % of gross margin | % of total business | % of gross margin |
| Total business | 506,358.08 | 100.0 | | 100.0 | | 100.0 | | 100.0 | | 100.0 | |
| Sales of farm products | 261,412.61 | 51.6 | | 48.0 | | 82.1 | | 84.0 | | 76.6 | |
| Paid to producers | 247,658.43 | 48.9 | | 46.5 | | 77.9 | | 74.4 | | 65.4 | |
| Gross margin | 13,754.18 | 2.7 | | 1.5 | | 4.2 | | 9.6 | | 11.2 | |
| Sales of merchandise | 242,009.52 | 47.8 | | 51.9 | | 15.0 | | 14.9 | | 22.9 | |
| Cost of merchandise | 226,571.68 | 44.7 | | 48.0 | | 12.0 | | 14.0 | | 22.3 | |
| Gross margin | 15,437.84 | 3.1 | | 3.9 | | 3.0 | | 0.9 | | 0.6 | |
| Other receipts | 2,935.95 | 0.6 | | 0.1 | | 2.9 | | 1.1 | | 0.5 | |
| Total gross margin | 32,127.97 | 6.4 | 100.0 | 5.5 | 100.0 | 10.1 | 100.0 | 11.6 | 100.0 | 12.3 | 100.0 |
| EXPENSES | | | | | | | | | | | |
| Wages and salaries | 11,027.61 | 2.2 | 34.3 | 0.5 | 8.9 | 3.7 | 36.8 | 9.3 | 80.4 | 7.4 | 60.5 |
| Rental | — | — | — | — | — | — | — | — | — | — | — |
| Depreciation | 498.54 | 0.1 | 1.6 | — | — | — | — | 0.3 | 2.1 | 0.2 | 1.3 |
| Supplies | 977.48 | 0.2 | 3.0 | 0.1 | 2.8 | 0.5 | 4.9 | 1.0 | 8.8 | — | — |
| Insurance | 1,311.15 | 0.3 | 4.1 | 0.3 | 4.8 | 0.4 | 4.4 | 0.2 | 1.7 | 0.3 | 2.4 |
| Taxes | 1,072.21 | 0.2 | 3.3 | 0.3 | 4.7 | 0.7 | 6.7 | 0.4 | 3.1 | 0.4 | 3.1 |
| Interest on borrowed money | 8,427.06 | 1.7 | 26.2 | 0.7 | 13.5 | 2.9 | 28.9 | 0.1 | 0.7 | 2.3 | 18.8 |
| Maintenance | 5,294.68 | 1.0 | 16.5 | 0.9 | 16.4 | 0.6 | 5.7 | 0.4 | 3.7 | 0.4 | 3.7 |
| Other | 549.21 | 0.1 | 1.7 | 0.4 | 6.9 | 0.5 | 4.6 | — | — | 0.8 | 6.3 |
| Total expenses | 29,157.94 | 5.8 | 90.7 | 3.2 | 58.0 | 9.3 | 92.0 | 11.7 | 100.5 | 11.8 | 96.1 |
| Net operating income | 2,970.03 | 0.6 | 9.3 | 2.3 | 42.0 | 0.8 | 8.0 | −0.1 | −0.5 | 0.5 | 3.9 |
| Other income | 23,465.52 | 4.6 | 73.0 | 7.0 | 126.8 | 21.2 | 210.2 | 0.1 | 0.9 | −4.3 | −34.6 |
| Net income for distribution | 26,435.55 | 5.2 | 82.3 | 9.3 | 168.8 | 22.0 | 218.2 | 0.0 | 0.4 | −3.8 | −30.7 |
| Dividends on capital | 401.49 | 0.1 | 1.3 | 1.0 | 19.2 | — | — | — | — | — | — |
| Total apportioned | 401.49 | 0.1 | 1.3 | 1.0 | 19.2 | — | — | — | — | — | — |
| Undivided income | 26,034.06 | 5.1 | 81.0 | 8.3 | 149.6 | 22.0 | 218.2 | 0.0 | 0.4 | −3.8 | −30.7 |

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* Individual plants are designated by letters K, L, M, etc.

TABLE 2.—COMPARATIVE OPERATING STATEMENTS OF TEN CO-OPERATIVE FRUIT COMPANIES IN NOVA SCOTIA FOR THE YEAR ENDING MAY 31, 1931*—*Concluded*

| | O | | P | | Q | | R | | S | | T | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | % of total business | % of gross margin | % of total business | % of gross margin | % of total business | % of gross margin | % of total business | % of gross margin | % of total business | % of gross margin | % of total business | % of gross margin |
| Total business | 100.0 | | 100.0 | | 100 0 | | 100.0 | | 100.0 | | 100.0 | |
| Sales of farm products | 78.0 | | 62.6 | | 68.2 | | 31 0 | | 42.9 | | 37.1 | |
| Paid to producers | 66.0 | | 60.5 | | 67.6 | | 29.0 | | 41.8 | | 35.3 | |
| Gross margin | 12.0 | | 2.1 | | 0.6 | | 2.0 | | 1.1 | | 1.8 | |
| Sales of merchandise | 21.7 | | 37.0 | | 31.4 | | 67.5 | | 57.0 | | 62.9 | |
| Cost of merchandise | 20.4 | | 35.8 | | 27.2 | | 61.3 | | 53.5 | | 61.2 | |
| Gross margin | 1.3 | | 1.2 | | 4.2 | | 6.2 | | 3.5 | | 1.7 | |
| Other receipts | 0.3 | | 0.4 | | 0.4 | | 1.5 | | 0.1 | | 0.0 | |
| Total gross margin | 13.6 | 100.0 | 3.7 | 100.0 | 5.2 | 100.0 | 9.7 | 100.0 | 4.7 | 100.0 | 3.5 | 100.0 |
| EXPENSES | | | | | | | | | | | | |
| Wages and salaries | 8.0 | 58.9 | — | — | 2.3 | 44.3 | 3.2 | 32.8 | 1.3 | 27.2 | — | — |
| Rental | — | — | — | — | — | — | — | — | — | — | — | — |
| Depreciation | 0.1 | 0.7 | 0.2 | 4.1 | 0.0 | 1.0 | 0.3 | 2.7 | 0.0 | 0.9 | 0.1 | 1.8 |
| Supplies | — | — | 0.6 | 16.3 | 0.1 | 1.4 | — | — | — | — | 0.2 | 5.1 |
| Insurance | 0.3 | 2.5 | 0.1 | 3.1 | — | — | 0.5 | 5.6 | 0.1 | 2.5 | 0.3 | 8.2 |
| Taxes | 0.6 | 4.2 | 0.1 | 3.3 | — | — | 0.5 | 5.7 | 0.2 | 4.8 | — | — |
| Interest on borrowed money | 2.8 | 20.6 | 0.7 | 18.2 | 0.8 | 14 7 | 3.9 | 40.3 | 1.9 | 39.3 | 1.3 | 36.9 |
| Plant maintenance | 1.1 | 7.9 | 1.7 | 44.9 | 0.4 | 8.6 | 1.2 | 12.3 | 0.3 | 5.3 | 1.7 | 49.0 |
| Other | 0.3 | 2.4 | 0.0 | 1.1 | — | — | — | — | 0.0 | 0.1 | 0.0 | 1.1 |
| Total expenses | 13.2 | 97.2 | 3.4 | 91.0 | 3.6 | 70.0 | 9.6 | 99.4 | 3.8 | 80.1 | 3.6 | 102.1 |
| Net operating income | 0.4 | 2.8 | 0.3 | 9.0 | 1.6 | 30.0 | 0.1 | 0.6 | 0.9 | 19.9 | −0.1 | −2.1 |
| Other income | 4.9 | 36.2 | 4.0 | 106.0 | 4.1 | 80.6 | 5.4 | 55.7 | 14.3 | 302.8 | — | — |
| Net income for distribution | 5.3 | 39.0 | 4.3 | 115.0 | 5.7 | 110.6 | 5.5 | 56.3 | 15.2 | 322.7 | −0.1 | −2.1 |
| Dividends on capital | — | — | — | — | — | — | — | — | — | — | — | — |
| Total apportioned | | | | | | | | | | | | |
| Undivided income | 5.3 | 39.0 | 4.3 | 115.0 | 5.7 | 110.6 | 5.5 | 56.3 | 15.2 | 322.7 | −0.1 | −2.1 |

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* Individual plants are designated by letters K, L, M, etc.

TABLE 3.—RATIO TESTS APPLIED TO OPERATIONS OF TEN CO-OPERATIVE FRUIT COMPANIES IN NOVA SCOTIA FOR THE SEASON 1930-31[1]

| | All[2] | K | L | M | N |
|---|---|---|---|---|---|
| Current assets to current liabilities | 0.91 to 1 | 2.20 | 0.74 | 1.00 | 0.57 |
| Worth to debt | 0.42 to 1 | 0.93 | 0.38 | 0.66 | 0.12 |
| Business to plant value | 3.14 to 1 | 3.91 | 0.79 | 5.32 | 2.84 |
| Net worth to fixed assets | 0.67 to 1 | 1.06 | 0.46 | 1.00 | 0.22 |
| Per cent working capital of total assets | — | 0.19 | — | 0.01 | — |
| Per cent net worth of all liabilities | 29.75 | 48.30 | 27.56 | 39.65 | 10.91 |
| Per cent expenses of business | 5.8 | 3.21 | 9.29 | 11.67 | 11.78 |
| Business per employee | $ — | 4,198 | 1,988 | 1,372 | 5,021 |
| Business per patron | $ 1,217 | 1,181 | 585 | 686 | 628 |

TABLE 3.—RATIO TESTS APPLIED TO OPERATIONS OF TEN CO-OPERATIVE FRUIT COMPANIES IN NOVA SCOTIA FOR THE SEASON 1930-31[1]—*Concluded*

| | O | P | Q | R | S | T |
|---|---|---|---|---|---|---|
| Current assets to current liabilities | 0.62 | 1.13 | 1.39 | 1.09 | 0.75 | 0.75 |
| Worth to debt | 0.33 | 0.84 | 0.56 | 0.41 | — | 0.59 |
| Business to plant value | 2.35 | 3.77 | 8.65 | 2.99 | 5.67 | 3.21 |
| Net worth to fixed assets | 0.46 | 0.91 | 1.15 | 0.94 | — | 0.67 |
| Per cent working capital of total assets | — | 0.06 | 0.19 | 0.06 | — | — |
| Per cent net worth of all liabilities | 24.88 | 45.50 | 35.81 | 29.30 | — | 37.00 |
| Per cent expenses of business | 13.20 | 3.41 | 3.61 | 9.62 | 3.77 | 3.62 |
| Business per employee | $ — | — | 5,991 | 8,118 | 5,533 | 6,124 |
| Business per patron | $ 342 | 812 | 2,330 | 1,827 | 885 | 2,156 |

[1] Individual plants are designated by letters K, L, M, etc.

[2] Considering the ratios in the form of a fraction, 1 is to be understood as the denominator in all cases.

of 8.8 cents on the sales dollar for supplies. If the surplus which would accrue from such a working arrangement were put aside in reserve, in one year there would be a fund built up which would reduce the mortgage by one-half and in five years practically the entire present indebtedness would be cleared off. This pre-supposes that the number of companies handling fruit are necessary and it is in the interest of the industry to maintain all of them in operation.

If there is duplication of services and under-capacity volume of business which this analysis and other surveys of the Nova Scotia fruit packing industry seem to indicate, then some of the warehouses may not be essential to the welfare of the industry. A recent investigation into the economic aspects of the apple industry in Nova Scotia points out that there are 25 warehouses on one branch line of 13.6 miles or an average of 1.8 warehouses per mile[3]. The majority of the plants were built in the time of horse drawn vehicles when close proximity to the orchard and packing house were more necessary than to-day. Improved roads and the motor truck have changed the situation. Regional reorganization with consolidation of a number of the low capacity houses would increase the volume per plant and should thereby reduce the cost per unit.

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[3] Longley, Willard V. Some economic aspects of the apple industry in Nova Scotia. N.S. Dept. Agr. Bull. 113. 1932.

## ECONOMIC LITERATURE

**Rye, The Production and Distribution of Coarse Grains, III.** Agricultural Branch, Dominion Bureau of Statistics, Department of Trade and Commerce, Ottawa, p. 32.

This publication is the third of a series dealing with statistical and other data relating to Canadian coarse grains, their place in world production and trade.

Rye has never assumed a very important place in cereal production in Canada, reflecting, of course, a limited market in a country where wheat is cultivated on a large scale. In 1933 the area sown was 583,500 acres, which represented 1.3% of the total area sown to the four main cereals for that year. The area devoted to rye has decreased rapidly during the last few years; in 1930 rye acreage reached its highest peak in the past ten years. Prior to the war the acreage was small and relatively stable. Under the stimulus of the war and post-war demand acreage increased from 111,280 acres in 1914 to 2,105,367 acres. Large decreases occurred in 1923 and 1924 but from 1925 to 1930 rye acreage rose steadily, after which time decreases again took place. It is apparent, therefore, that the development of the rye industry in Canada has been marked by radical increases and decreases.

In spite of the increase in wheat production and consumption in the past thirty years, the world still consumes from 1½ to 2 billion bushels of rye annually. The fact that rye is still the chief food of millions of people indicates in a tangible way the merits of the grain as a bread stuff. Rye bread is most generally used in Russia, Germany and Poland where a large part of the world's crop is produced. In Canada the distilling industry provides the largest industrial outlet for surplus rye, small amounts are used for human food products while a considerable proportion is fed or otherwise consumed on farms.

In addition to the information on the production and uses of rye which has been briefly summarized in this short review the report also outlines the world production and trade in rye, Canada's trade, prices of rye in Canada and governmental policies in respect to rye in foreign countries.

**Kraemer, Erich, and Erdman, H. E.** History of Co-operation in the Marketing of California Fresh Deciduous Fruits. Bulletin 55, Agricultural Experimental Station, University of California.

The authors of this bulletin have presented a comprehensive review of the development of co-operative marketing of California fresh deciduous fruits. The history of the California deciduous fruit tree industry dates back to the beginning of the settlement of Alta, California, by the Franciscan fathers in 1769. The first real evidence of commercial fruit production, however, did not appear until the days of the Gold Rush in 1849. From this time onward the authors have traced the development of the various organizations which led up to or fostered the co-operative marketing of California fresh deciduous fruit. The earliest movement for collective actions in connection with the sale of fruit was probably the California Fruit Growers' and Dealers' Association which commenced operations in 1869. Later the California Fruit Union was organized and in time it was replaced by the California Fruit Growers' and Shippers' Association. The California Fruit Union created in 1885 provided the first plan for the establishment of a state-wide grower-owned and grower-controlled co-operative marketing system for fresh deciduous fruits. After the first year, it became a grower-dealer organization. Having lost its grower character and having failed to obtain the expected market control, it passed out of existence during the business depression of 1894. In 1901 another state-wide organization called the California Fresh Fruit Exchange (now the California Fruit Exchange) was formed. At present the Exchange co-ordinates the activities of the large majority of the existing co-operative associations for fresh deciduous fruits and has spread its grower connections over the entire state and into Arizona. In collaboration with the California Fruit Growers' Exchange it has also built up an effective sales system and has made good progress in the development of an export business. To-day approximately 8,000 growers are organized in some 90 local co-operative associations which handle about 11% of the fresh fruits shipped from California, as well as some portion of such commodities sold in the state itself. Most of these organizations are federated with the California Fruit Exchange.

The basic reason for the urge to form co-operative associations throughout the period of sixty-odd years has been low prices to growers. The principal reasons given in explanation for low prices were:—

"(1) High freight and refrigeration charges. (2) High charges by California packers and shippers and by dealers in the East. (3) Dishonest or questionable practices on the part of shippers or on the part of the trade in eastern markets. (4) Lack of aggressiveness on the part of private shippers in developing new markets and correcting evils in transportation or in the eastern markets. (5) Disorganization of markets."

Like many other co-operative movements this one has experienced difficulty in obtaining sufficient grower control which is necessary to overcome disorderly marketing. Because of this "there have been repeated attempts to combine grower and dealer interests so as to include in the organization practically all the fruit."

Kolb, J. H., and Polson, R. A. Trends in Town-Country Relations. Research Bulletin 117, Agricultural Experiment Station, University of Wisconsin and the United States Department of Agriculture Co-operating.

A study of the trends in town-country relationships is important for it shows the necessity of building town and country life together. Such a study was made in Walworth County, Wisconsin, in 1929, and the results are presented in this bulletin. Comparisons are made with a similar study conducted in 1913.

There have been many general changes in Walworth County since 1913. The percentage of native born rose from 75% to 89.5%; the proportion living in the open country and unincorporated centers has been decreasing. The population of incorporated places increased 13 5%. Changes in dairying, the chief industry, have been made to meet the city demand for milk. Villages and small town receiving and processing plants have been replacing small milk stations and creameries.

There have been changes in seven main service areas. Library service areas have increased 158% since 1913; the high school has helped to bring about this change. Milk marketing areas have made a net gain of 64%; this has been due to improved roads, truck transportation and the tendency toward centralized control. The net expansion in high school areas has been 49%. Rural enrolment ranges from 40 to 50% of the total depending on the size of the center. Grocery services have expanded 22%. Chain stores now operate in every center with over 700 population. The old general store has been replaced by a type which carries a few "lines". On the whole there has been no marked increase in the affiliation of country people with the village or town church. Changes in areas for dry goods services have been erratic. Country people have changed their wants more rapidly than the men in the business have changed their methods to satisfy them. Banking service areas show the least net change, though six centers have lost territory while five gained. "Banking service, like grocery and dry goods services, seems to be gravitating toward those men and institutions which are aggressively attempting to give a modern type of service adapted to their country and village or town constituents."

Farm families use on the average four service centers per family, namely, a cross roads, hamlet or very small village center, two villages or small town centers, some city center. Mail order houses are used as well. Country centers are important for restricted merchandise and for primary educational and church services. Towns and villages are increasingly becoming the main centers for many of the services required by farm families. It can now be said that town and country are uniting to form a larger rural community. Farm families go to urban centers for special medical and hospital care, good clothes, and furniture.

## NOTES

A statement concerning the Wheat Agreement was made by the Rt. Hon. R. B. Bennett in the House of Commons on March 13, 1934. Legislation has been agreed upon by the four Governments and has been introduced in the legislatures of the provinces of Manitoba, Saskatchewan and Alberta. The proposed legislation empowers the Lieutenant Governor in Council in each of the provinces to set up an emergency Wheat Control Board with power to license and restrict within the province sales and deliveries of wheat. In lieu of separate provincial Boards a joint Board may be set up by the three prairie provinces or by one or more or all of the provinces in conjunction with the Dominion. A province can enact legislation dealing with sales and deliveries within its own borders, but enabling legislation by the Dominion is required to permit control of sales and deliveries outside of a province. With respect to a wheat Board, Parliament will be invited to enact the necessary legislation to enable the Government, in the event of the four governments being of the opinion that the necessity for the same exists, to co-operate with the provinces in establishing a Board with all the necessary authority and powers to deal with any situation which may arise.

The bills to be introduced in the Legislatures of the several provinces will provide also that the Lieutenant Governor in Council shall have power by order-in-council to make all such orders, rules and regulations, and do all such acts and things as in the opinion of the Lieutenant Governor in Council may be necessary and requisite to bring the production of wheat in the province concerned in the year 1934 into proper alignment with the estimated current export demand for the crop season 1934-35 and normal domestic requirements in the same period, having regard to the quota applicable to the Dominion of Canada as provided by Article 2 of the London Wheat Agreement.

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"The Agricultural Situation" is the title of a new publication issued jointly by the Department of Agriculture and the Department of Trade and Commerce, Ottawa.

The preparation of such a report was recommended by the National Advisory Committee on Agricultural Services for Canada which appointed a sub-committee composed of Dr. J. F. Booth, Economics Branch, Department of Agriculture; Dr. T. W. Grindley, Agricultural Branch, Dominion Bureau of Statistics, and Dr. J. E. Lattimer, Macdonald College, P.Q., to study the matter further and to make plans to give effect to their recommendation. The sub-committee therefore arranged for a meeting of representatives of the various branches of the Department of Agriculture, the Commercial Intelligence Service, and the Dominion Bureau of Statistics. At this meeting plans for the formation of "commodity committees" to prepare reports on specified products were developed. The reports of these committees were subsequently received by a "committee of the whole" at which representatives of the provinces of Quebec, Ontario, Saskatchewan and British Columbia were present. The reports were finally edited by a small committee and made available early in March.

The purpose of such a report is to assemble and interpret statistical and other information necessary in planning farm production and marketing policies. Such information it is felt will be of value to extension workers, farmers, and others concerned with the problems of agricultural industry.

A report of this nature cannot be expected to cover all commodities or to be as complete in respect to certain products as to others, but it brings to the farmer in a concise manner information which has been compiled by several agencies. It moreover represents the combined viewpoints of those engaged in diverse fields of research, administration and extension work.

SCIENTIFIC AGRICULTURE

Vol. XIV MAY, 1934 No. 9

# LEGUMES AND THE NITROGEN PROBLEM IN THE DRY FARMING AREAS OF WESTERN CANADA

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[Received for publication January 30, 1934]

Authorities are in general agreement that land used for grain production, without the use of manure or fertilizers, gradually loses a portion of its nitrogen. There is also a general agreement that such a practice is agronomically unsound. Shutt (*6*) found that the nitrogen content of Portage la Prairie, Manitoba, soil, used in the production of grain crops for 25 years, changed from 0.651% to 0.506%. Similarly, soil from the Dominion Experimental Farm, Indian Head, Saskatchewan, in a period of 22 years showed a loss in nitrogen content from 0.317% to 0.254%. Expressed in pounds of nitrogen per acre in a soil depth of 8 inches the loss in the Indian Head soil amounted to 2,340 pounds from an initial total of 7,420 pounds. Subsequent investigation showed that this relatively rapid loss of nitrogen was not sustained, although the system of grain production had continued without change. Data secured some 16 years later even showed a slight gain in nitrogen. It would be incorrect, as Shutt points out, to assume that the heavy losses noted in cultivated soils are caused entirely by the grain crops. Analyses of these account for only one-third of the total loss observed. Alway (*1*) gives an example to show that soil, kept cultivated year after year without cropping of any description, may lose nitrogen as rapidly as that where fallow and crop alternate. The evidence at any rate indicates quite clearly that newly broken soil in Western Canada, cropped according to the practices common in this area, suffers an appreciable loss in nitrogen in a comparatively short time. The significance of this loss is not at present apparent. Western Canadian soils, according to reports of the Grain Research Laboratory, continue to produce wheat of high quality, particularly the soils in the so-called open plains section, where the major areas devoted to wheat production are located.

Field crops produced in the three western provinces of Manitoba, Saskatchewan and Alberta are essentially cereal crops, which are either sold off the farm or are used to form an important constituent in the rations of live stock. In 1928, the total area under cultivation in the three provinces was 51,118,128 acres. Wheat alone occupied 23,158,505 acres and the three major cereals, wheat, oats and barley, combined with cereal hays and summer-fallow, occupied an area of 47,107,267 acres, or 92% of the total cultivated area. The reason for this is not difficult to determine. Over extensive areas climatic conditions are such as to favour cereal production and to discourage other forms of husbandry.

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The present cultivated area of the three western provinces extends, roughly, for 800 miles east and west and 350 miles north and south with a broad belt centering on the Peace river in northwest Alberta. While grain crops are produced over this whole area appreciable differences in climate exist, chiefly with respect to precipitation, wind movement and evaporation. Generally speaking favourable moisture conditions exist over an area bordering along the east, north and west. This area comprises the so-called wooded and park areas to the east and north and the foothills country of the west. Within these limits lies the open plains area, which is centred in the province of Saskatchewan and is bordered on the south by the United States boundary. The Dominion Experimental Stations at Morden, Manitoba, and Lacombe, Alberta, are within the areas of favourable moisture conditions, while those at Scott and Swift Current, Saskatchewan, and Lethbridge, Alberta, are on the open plains. In these latter areas the system of dry-land farming is practised. The term "dry-land farming" indicates that under this system special precautions must be taken to conserve moisture as this is the limiting factor in crop production. Nearly two-thirds of the total cultivated area of Saskatchewan lies within the area in which dry-land farming is necessary, a lesser proportion in Alberta, and a relatively small proportion in Manitoba. Of the total wheat acreage of the three provinces about 60% lies within the area of dry-land farming. A scarcity of moisture here results in very low yields of wheat, although this is off-set to some extent by a high quality of grain. In the dry-land farming areas moisture conservation is by far the most important agricultural problem. It determines, in fact, the type of agriculture.

Some writers have professed to see in the practice of grain growing by Western Canadian farmers an irrational system of husbandry. It is believed that continued production of cereal crops will ultimately result in the exhaustion of soil fertility, and in support of this such factors as soil drifting, the menace of weeds and pathological difficulties are cited as evidence of an approaching condition when grain growing will be impossible. The recent studies of Kravkov (5), Tulaikov and Kuzmin (7), however, with reference to conditions in the cereal producing sections of Russia, which resemble those of Western Canada very closely, do not support this gloomy view. The yields of crops at present secured under relatively dry conditions cannot be taken as a criterion of the potential productive power of the soil.

When grain production forms the major farm activity supplies of farm manure are sufficient to replace only a fraction of the nitrogen lost during soil cultivation. Commercial fertilizers are relatively expensive, although the use of certain forms of fertilizer is increasing. The legume crops, which by the action of symbiotic bacteria are able to fix atmospheric nitrogen, have been hailed, therefore, as a cheap and convenient means of maintaining soil nitrogen and at the same time furnishing a supply of valuable fodder. Unfortunately these desirable results are not always realized. Legume crops are difficult to establish, in fact Gainey (3) points out that there are no legume crops well adapted for most semi-arid soils. When a stand of such crops is secured it is frequently at the expense of the yields of the cereals which follow.

The powerful influence of moisture in crop production under dry-land farming conditions is brought out in some soil moisture experiments conducted at the Swift Current station. In these experiments crops are grown in soil contained in deep water-tight tanks. The sole source of moisture supply for these crops is the natural precipitation, while conditions for growth are made to agree as closely as possible with those governing field crops. The use of deep tanks permits a very accurate check on moisture utilization, without affecting crop growth, by observing changes in weight of the whole equipment. In 1931 a series of similar three year rotations was begun. The rotation consists of: first year wheat seeded to sweet clover, second year sweet clover, third year wheat. The rotation is triplicated so that one sweet clover crop can be ploughed in mid-July, a second in mid-October, and a third in the following spring just prior to the seeding of wheat. Each year in the rotation is represented by duplicate tanks. The whole experiment is also repeated with Western rye grass in place of sweet clover. The influence of these crops on available soil moisture and this in turn upon the yield of wheat is indicated in Table 1.

TABLE 1.—WHEAT AFTER SWEET CLOVER AND WESTERN RYE GRASS. AVAILABLE SOIL MOISTURE AND YIELDS OF WHEAT. SWIFT CURRENT, SASKATCHEWAN, 1933

| Sod ploughed | Available soil moisture | | Yield of wheat per acre | |
|---|---|---|---|---|
| | Wheat after sweet clover, inches | Wheat after western rye grass, inches | After sweet clover, bush. | After western rye grass, bush. |
| July 15, 1932 | 4.42 | 4.59 | 19.4 | 18.2 |
| Oct. 15, 1932 | 1.61 | 1.20 | 7.9 | 4.0 |
| Spring, 1933 | 0.94 | 0.47 | 6.2 | 2.1 |

For convenience the above data have been expressed on a "bushels per acre" basis. Actually, of course, the yields of grain were quite small and were recorded as grams of grain. The utmost care was observed in harvesting these crops which were threshed by hand rubbing in preference to using any small machine. The conversion of grams per tank to bushels per acre was made by multiplying each result by a suitable factor, in this case 1.302.

In a standard three-year rotation of wheat, wheat and summer-fallow, also conducted with grain grown in tanks, the crop following summer-fallow yielded at the rate of 29.1 bushels per acre and that on stubble 11.0 bushels. The amounts of available water secured from the soil by these crops were 6.87 inches and 2.67 inches respectively. The term available soil moisture, as distinct from unavailable soil moisture, represents the amount of moisture present at seeding time which can be utilized by a growing crop. Most crops usually exhaust all available soil moisture during their growth, although the soil at harvest time still contains a very small amount termed the unavailable moisture.

Previous experiments have shown that, under prevailing conditions, no moisture is conserved in the soil as long as this supports a vegetative growth. The summer-fallow provides a most favourable means for moisture conservation as the land remains bare for the longest period. Whatever contribution was made by the sweet clover towards soil improvement in this experiment, it was effectively masked, as the data indicate, by the moisture factor.

A somewhat similar experiment, discontinued in 1930, was also conducted with the use of soil contained in deep tanks. The rotation was of three years duration and consisted of wheat seeded to sweet clover, sweet clover hay, summer-fallow. With a period of summer-fallow intervening between the sweet clover hay and the wheat crops, there was an opportunity for the soil to conserve moisture and thus permit the favourable influence of the sweet clover to become evident. As in the previous example natural precipitation formed the sole source of moisture supply for the crops. Results of this experiment over a period of six years are given in Table 2. Data for wheat produced under similar conditions in a standard rotation of wheat, wheat, summer-fallow are included.

TABLE 2.—WHEAT ON SUMMER-FALLOW. SWIFT CURRENT, SASKATCHEWAN, 1925–1930

| — | Rainfall, inches | Available soil moisture | | Yield of wheat per acre | |
|---|---|---|---|---|---|
| | | Wheat after sweet clover, inches | Wheat after wheat, inches | After sweet clover, bush. | After wheat, bush. |
| 1925 | 3 65 | 9 70 | 7 98 | 35 5 | 32 8 |
| 1926 | 6 00 | 6 94 | 8 24 | 36 6 | 44 9 |
| 1927 | 10 67 | 5 02 | 5 02 | 35 9 | 61 4 |
| 1928 | 7 63 | 9 74 | 9 77 | 63 7 | 59 9 |
| 1929 | 6 12 | 6 28 | 5 61 | 27 2 | 23.9 |
| 1930 | 4 83 | 4 19 | 4 55 | 20 2 | 25 4 |

In the standard three year rotation the fallow period, or period of moisture conservation in the soil, began immediately after harvest in August and proceeded for approximately twenty months. In the rotation containing sweet clover the length of the fallow period varied from season to season. Ordinarily the hay crop was harvested about one month before grain crops. It was then left to provide an aftermath. When this failed the soil had a longer time in which to conserve moisture; the process of ploughing sod has no appreciable influence on moisture conservation providing the soil is free of vegetation. On the other hand a continued growth of sweet clover effectively prevented moisture conservation until the crop was ploughed under.

The data bring out some very interesting facts. Wheat, in the wheat, sweet clover, summer-fallow rotation yielded higher than wheat in the standard rotation in 1925, 1928 and 1929. The yields of wheat secured in 1925 might possibly not be considered significant with the experiment conducted on such a small scale and also with such an appreciable difference in available soil moisture. Taking the above ground portions of these crops, however, that is to say, grain and straw combined, the evapotranspiration ratios in this particular season were not appreciably different, being 471 for wheat in the sweet clover rotation and 481 in the standard rotation. The total crop in the former case was 17% greater, but the grain yield was only 8% higher. Apparently the influence of the sweet clover was to lessen the proportion of grain to total crop. This influence appears to be quite marked in the 1927 results. Both crops secured the same amount of moisture, but the yields of grain were decidedly different. In this case the wheat from the standard rotation formed 40.4% of the total crop, while that from the sweet clover rotation was only 29.3%. A possible explanation for this difference may be found in a condition that has been frequently observed. A luxuriant growth of crop is usually indicative of a high transpiration rate. The transpiration from a growing crop of grain may, and usually does in dry-land farming areas, proceed at a rate much greater than can be maintained by the natural rainfall (*2*). Eventually soil moisture may be practically exhausted while the demands of the crop for moisture are still quite urgent. Under such conditions the potential yields of grain may be greatly reduced in a comparatively short time.

The 1928 season was perhaps the most favourable for crop production in the series. Soil moisture was abundant and this was supplemented by a normal amount of seasonal rainfall. The wheat crops in the two rotations utilized approximately the same amounts of water. The evapo-transpiration ratios were quite low, 342 for wheat in the sweet clover rotation and 364 for wheat in the standard rotation, indicating a remarkable efficiency in the use of water by the two crops. The proportion of grain to total crop, usually around 40%, was 33.1% in both cases. It is therefore quite possible that the yields indicate a significantly favourable influence from the sweet clover.

At the Indian Head, Saskatchewan, farm, wheat following alfalfa, in an alfalfa, summer-fallow, wheat rotation, yielded 24.7 bushels per acre as an average for eight years. In another experiment, conducted during the same period, wheat following summer-fallow in a rotation wheat, summer-fallow, wheat, yielded 33.5 bushels per acre. On the Lacombe, Alberta, station in a similar experiment wheat following alfalfa, but with a period of summer-fallow intervening, yielded as an average of nine years results 28.1 bushels per acre, while wheat on summer-fallow in the standard rotation yielded 32.0 bushels. The spread in the latter case is not very wide as one would naturally expect because moisture conditions at Lacombe are more favourable than those at Indian Head and more so than those at Swift Current. It is indeed surprising to find the influence of alfalfa upon soil moisture persisting over such a long period, but the work of Kiesselbach, Russel and Anderson (*4*) indicates that several years of complete fallow may be necessary under some conditions to restore soil moisture utilized by alfalfa.

The above rotations, wheat, legume, summer-fallow, while utilized experimentally, are not adapted to farmers' requirements in the drier areas. At the Dominion Experimental Stations at Morden, Manitoba, and Lacombe, Alberta, it is not uncommon to find sweet clover seeded with wheat to attain a height in the same season equal to that of the wheat plants. No such desirable results have been secured at the Swift Current and Lethbridge stations under the prevailing climatic conditions.

It may be urged with some justification that a supply of admittedly valuable forage should counterbalance the loss in wheat yields when legumes and wheat are grown in succession. This, however, only holds in certain areas. Where the least depression in wheat yields occurs, through the action of previous crops in exhausting soil moisture, legume crops are successfully grown and give very satisfactory yields. Conversely legume and perennial hay crops are difficult to establish and give poor to only fair yields in areas where the moisture problem exists. Under such conditions farmers concentrate on the production of cereal crops, not because these offer promise of rich rewards for a minimum of physical effort—relatively low yields militate against this possibility—but because the practice ensures the most effective utilization of limited moisture resources. For his supplies of forage the farmer also relies upon cereals cut green for hay. On this point the 1933 issue of the *Guide to Saskatchewan Agriculture* comments as follows: "Where moisture is the chief limiting factor in the growth of forage crops, as it is in many parts of Saskatchewan, annual crops must necessarily play an important part in supplying the feed requirements for live stock. Perennial crops have their own sphere of usefulness, but annual crops are a more dependable source of forage, one year with another, since they may be grown on land which has a certain amount of reserve moisture. The relative importance of annual crops for hay and pasture increases as the moisture supply becomes more restricted". Annual hay crops it might be mentioned consist chiefly of oats, barley and rye. On the same topic the superintendent of the Scott, Saskatchewan, station in his report for 1930 remarks: "Annual hay crops continue to supply the large portion of cultivated forage crops in Northwestern Saskatchewan. They are more dependable and usually give fair yields". In brief, the areas in which annual hay crops are produced correspond to those in which dry-land farming is practised.

## CONCLUSIONS

1. Extensive areas in Western Canada are utilized almost exclusively for the production of cereal crops.

2. Such a practice results in the loss of considerable amounts of soil nitrogen, although continued deterioration proceeds much slower beyond a certain point. Cereal production with restricted animal husbandry permits the return to the soil of only a small quantity of nitrogen by means of farm manure.

3. The valuable property of legume crops in indirectly replenishing soil nitrogen cannot be fully utilized under dry-land farming conditions as the moisture hazard restricts the growth of such crops.

4. The nitrogen problem, if such exists in the extensive dry-land farming areas of Western Canada, is destined to remain unless some radically new solution is found.

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## RESUME

**LES LÉGUMINEUSES ET LE PROBLÈME DE L'AZOTE DANS LES RÉGIONS DE CULTURE EN TERRE SÈCHE DANS L'OUEST DU CANADA.** S. Barnes, Station expérimentale fédérale, Swift Current, Sask.

La production de céréales sans l'emploi de fumier ou d'engrais chimiques, résulte en une perte appréciable de l'azote du sol; cette perte s'est montée, dans un cas, à 2,340 livres pendant une période de 22 ans, sur un total, au début, de 7,420 livres. La culture des légumineuses est assez risquée, et l'aptitude spéciale qu'elles ont de restaurer l'azote du sol peut être paralysée par un manque d'humidité. Le blé cultivé après une jachère a donné 29.1 boisseaux; après du mélilot qui avait été enfoui à la charrue en juillet précédent, 19 4 boisseaux; après du mélilot qui avait été enfoui à la charrue en octobre précédent, 7.9 boisseaux, et après du mélilot qui avait été enfoui au printemps, juste avant les semailles du blé, seulement 6.2 boisseaux. L'effet favorable des légumineuses est de plus en plus apparent à mesure que la proportion d'eau dans le sol augmente.

# NOTES ON THE LESSER BUDMOTH, *RECURVARIA NANELLA* HBN.

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(Received for publication February 1, 1934)

The lesser budmoth, first recorded in Nova Scotia in 1915, was evidently quite numerous, at least in certain areas in the fruit district during that year. For the following twelve years the insect was more or less forgotten, due probably to insufficient numbers to attract attention. During the spring of 1927, when the writer was making a study of orchard insects, a few larvae closely resembling those of *Spilonota ocellana* D. & S., were noticed in the vicinity of Annapolis Royal. An attempt was made at this time to rear the larvae and carry the insect through its various life stages. This effort, however, was more or less a failure as the larvae all died before reaching maturity. The insect did not again attract the writer's attention until the spring of 1929, when larvae were frequently observed in various localities in the Annapolis Valley, with moderately infested orchards at Spa Springs and Berwick.

The life-history of *Recurvaria nanella* Hbn. is very similar to that of *Spilonota ocellana* D. & S. and the larva, at least in most of its stages, also closely resembles that of the more common and destructive budmoth. Due to the great prominence of the latter insect as an orchard pest in Nova Scotia at this period, a life-history study was made of *Recurvaria nanella* Hbn. and notes on its habits recorded.

## ECONOMIC HISTORY

From a brief survey of the available literature it is evident that *Recurvaria nanella* Hbn. is a European species which is mentioned in entomological writings as early as 1776. In America, Scott and Paine report that the first specimens were obtained from Pennsylvania in 1903. Since that year it has been reported from various fruit growing States. In Canada, it has been reported from Ontario and Nova Scotia. In 1915, Dustan devoted some time to the life-history of this species in Nova Scotia, which was evidently the first record of its presence in the province. The larvae have been reported as feeding on apple, plum, apricot, pear, quince, peach, cherry and hawthorn. The writer has only observed the larvae feeding on apple, but no special effort was made to find it upon other host plants.

The various writers differ somewhat in their rating of the lesser budmoth as a fruit pest. From England it has been reported as feeding on pear and apricot, the latter crop being completely ruined in some instances. Records from Germany indicate that foliage of fruit trees became deformed to a pronounced extent. Other writers mention this species in a more or less casual manner, leaving the impression that it was a minor pest. Dustan found it common in Nova Scotia, at Kentville, but the resulting injury was apparently not of a serious nature. Unlike the eye-spotted budmoth, the larvae do not scar the fruit, and from the writer's experience there appears no cause to consider the lesser budmoth as a serious orchard pest. At the same time it must not be assumed that the larvae are not capable of causing much injury to fruit trees, especially to the buds in the spring of the year, should there be an increase to excessive numbers. As there are no records to indicate that this has so far occurred in Nova Scotia, *Recurvaria nanella* Hbn. must, for the present at least, be considered as a minor pest in the Annapolis Valley.

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It may be further emphasized that the larvae are easily confused with those of *Spilonota ocellana* D. & S. and that fruit growers therefore should endeavour to avoid mistaking this species for the more destructive orchard insect.

### LARVAE COMPARED WITH SPILONOTA OCELLANA D. & S.

The larvae of these two species of budmoths are present upon the trees at the same time, and although possibly not in corresponding instars are at least comparable in this respect.

It is during the first few weeks in the spring after emerging from their winter quarters that confusion is most likely to occur. At this time, however, it should not be difficult to distinguish characters with the aid of a hand lens which will in most instances separate and thus identify the larvae of these two species. The larvae of both species in the spring are brown, but those of *Recurvaria nanella* Hbn. are of a lighter shade, slightly mottled, with a decided velvety appearance and in size are somewhat smaller. The tubercles are smaller, less produced, and not rugose like those of *Spilonota ocellana* D. & S. The setae are shorter, finer and somewhat paler. Other writers have stated that the larvae lose their anal plate in the spring. From the writer's observations the anal plate at the last larval moult changes from a chocolate brown to a colour that blends so well with the body it is not readily distinguished from the surrounding surface. This change of colour is apparently what occurs and not an actual loss of the anal plate. In contrast, the anal plate of the eye-spotted budmoth remains dark brown throughout the entire larval period, so that when the lesser budmoth is observed in the last instar this constitutes a further distinguishing characteristic. As the larvae approach maturity confusion is less likely to occur, as the larvae of *Recurvaria nanella* Hbn. frequently assume a greenish or occasionally a brick-red colour and it is not unusual to observe a mixture or mottling of these two colours.

During the early instars of the lesser budmoth previous to its hibernating for the winter, the larvae are typical leaf miners, feeding entirely within the tissues of the leaf. In this respect they differ so strikingly from the eye-spotted budmoth that identity at this time is not difficult.

*Pupa.*—The pupa is less than a quarter of an inch in length, green when first formed but soon turning to a golden brown. It may be found at any location on the trunk or branches where rough bark is present. A favourite place is in the angle of limbs where some protection is afforded. It is well concealed under the loose bark in a small cell lined with silk. In this respect the location and cells in which it is found resemble those of the hibernating codling moth larvae. As previously mentioned, a few larvae fail to desert the foliage and these pupate in their feeding positions, but this constitutes but a small percentage of the total.

The first pupa was found at the insectary at Annapolis Royal on June 19. It would seem that pupation commenced a few days earlier under natural conditions at Berwick, for on June 21 it was evident that somewhat more than 50% of the larvae had pupated.

From Table 4 it is evident that the pupal period lasts from twenty-four to twenty-seven days, with an average of twenty-five days for this stage.

## LIFE-HISTORY AND HABITS

*Adult.*—The adults in 1929 began to emerge at Annapolis Royal from field collected pupae on July 8, and continued to emerge until July 30, or for a period of about three weeks. This appeared to parallel the emergence under field conditions, as one empty pupal case was observed outside on July 6, although no adults were in evidence for a few days later. On July 21 the adults at Berwick appeared to be at about their maximum numbers. In the cages males were the first to emerge, preceding the females by five days. At the close of this period females continued to appear four days after males ceased to emerge.

It was difficult to obtain mating and egg deposition under artificial conditions. The rearing cages were lantern globes placed over potted apple seedlings, but from nearly fifty matings only one female oviposited. In this particular cage a male and female were confined on July 8. On July 11.there were deposited 15 eggs, and during the following twelve days 39 more were laid, totalling 54 eggs. The female was dissected at death and 49 well developed eggs were obtained from the ovaries, making a total of 103 eggs. Two other females failing to oviposit were dissected at death and 74 and 81 eggs respectively obtained. Other females were examined but the eggs were so immature in the ovaries that accurate counts could not be made. These few records indicate that the egg capacity of the females probably varies from about 75 to slightly more than 100 eggs.

The female that oviposited in the cage died on July 29 and the male on August 1; the length of life of these mated individuals therefore, was 21 days for the female and 24 days for the male. In the other cages where no eggs were deposited the females lived from 20 to 25 days, and the males 19 to 22 days.

The adult's colour of grey and black endows it with a decided protective colouration, when in its natural habitat. The moths are usually found during the day at rest upon the trunks of the trees and blend so well in colour with the surrounding surface that they are difficult to distinguish. When disturbed they fly quickly away in a sort of circular flight, returning in a few moments, usually to the same tree, coming at rest again upon the trunk or dropping to the grass beneath. It is evident that this restricted flight prevents any rapid spread in the adult stage. This may be advanced as a factor for finding the insect very patchy in infested orchards. The adults were more active at night, but only feebly attracted to light.

In the course of the rearing work there was evidence of strong sexual attraction. The breeding cages were placed along one side of the insectory on a shelf about one foot from the outside wire screening. On July 14, eleven adults were captured on this wire outside and for the following six days from two to five were taken each day. These adults were all males and always resting on the wire at a point nearest to the caged females on the inside. This hardly seems a chance occurrence as the insect that year could scarcely be found about Annapolis Royal, and it appears that the males were attracted to the insectary by the females.

*Eggs.*—The eggs are only about one-sixtieth of an inch in length, somewhat cylindrical, and yellow in colour. In the breeding cages the eggs were laid under the bud scales, under the edge of next year's buds and a few at the base of the leaf petiole. They were deposited in groups, and under one bud scale 24 eggs were counted, but in most instances only 2 to 6 were found together. The eggs, although in contact, were apparently not adhering to each other. In the orchard the eggs were deposited upon the under side of the leaves near the larger veins, and on the leaf petioles. The eggs were placed loosely among the pubescence or hairs and apparently retained upon the foliage by this means. A careful search of the twigs revealed no eggs under bud scales, etc., as was found on the potted seedlings.

The incubation period is evidently about 23 to 24 days. Eggs deposited in the cage on July 11 began to hatch on August 4. The remaining eggs laid in confinement were deposited between the dates of July 11 and 23. The last larva to emerge from these eggs was on August 15. Taking into consideration the eggs laid on the last date would indicate an incubation period of 23 days.

*Larva previous to hibernating.*—For a few days before emerging the dark head of the larva can be observed through the egg shell, first as a dusky spot and later the head capsule becomes definitely outlined. The abdomen can usually be traced, but is very faint due to its pale colour. The tiny larva is seen curled up tightly within the egg, the head at the flattened end. A small rent is made in the egg shell from which the larva at once escapes. The larvae are at first less than one twenty-fifth of an inch in length, with a black head and pale body. Previous to hibernation for the winter they are typical leaf miners and in order to gain entrance to the leaf tissues a small circular portion is eaten in the more favoured positions between the veins on the under surface of the leaf. At first the mine is a more or less straight narrow trail but becomes widened and branched as feeding progresses. As these mines turn brown on the upper as well as the lower leaf surface infested foliage is readily located in the orchard. The small particles of frass are ejected from the mine and collect to a certain extent about the entrance. The head capsule at moulting is also usually ejected and frequently found adhering to the frass. After moulting either three or four times in the mines, the larvae desert the foliage to find suitable locations on the limbs to hibernate for the winter.

It was difficult to follow the larvae in the mines and obtain exact dates of moulting. However, daily records with reared larvae, together with observations in infested orchards, rendered it possible to obtain quite

TABLE 1.—LENGTH OF FEEDING PERIOD PREVIOUS TO HIBERNATING OF *Recurvaria nanella* HBN., ANNAPOLIS ROYAL, N.S., 1929

| Period of larval emergence | Period larvae hibernating | Length of indicated feeding period |
|---|---|---|
| Aug. 4 to 15 | Sept. 7 to 28 | 34 to 44 days |

accurate data in this regard. Larvae that hatched on August 4 ceased feeding on September 7. Likewise those hatching on August 15 deserted the foliage on September 28 to prepare winter quarters. These records coincided very closely with observations made outside under natural conditions. The first hibernaculum to be found in the orchard was on September 10 and the last larva observed hibernating was on October 3. The insect's most active hibernating period during 1929 was from September 15 to 25. Frequent measurements of head widths during the feeding period indicated that the larvae moult either three or four times before hibernating. The following is the average widths of head capsules of the early instars.

TABLE 2.—TOTAL AVERAGE WIDTH OF HEAD CAPSULE INCLUDING HIBERNATING INSTAR OF *Recurvaria nanella* HBN., ANNAPOLIS ROYAL, N.S., 1929

| 1st instar | 2nd instar | 3rd instar | 4th instar | 5th instar |
|---|---|---|---|---|
| .129 mm. | .178 mm. | 243 mm. | 293 mm. | 356 mm. |

The hibernacula are to be found on the smaller outer limbs of the trees, under old bud scales or bits of loose bark, in fact most any favourable location except on the smooth bark. They are constructed of tightly woven silk which the larva spins about itself, covered on the outside with fine pellets of dark frass, and in outward appearance are much like those spun by *Spilonota ocellana* D. & S., although somewhat smaller and not so readily observed. Like the latter insect, the larvae moult when the hibernaculum is partly constructed. After hibernation was complete measurements were made of the head width, the results of which go to show that the winter is passed in either the fourth or fifth instar. The cast head was frequently broken or distorted, so that it was only possible to obtain accurate measurements in a few instances as noted in Table 3.

TABLE 3.—WIDTH OF CAST HEAD AND OF LARVAE IN HIBERNACULA *Recurvaria nanella* HBN., ANNAPOLIS ROYAL, N.S., 1929.

| Width of cast head | Width of head of larva in hibernaculum | Instar of larva in hibernaculum | Width of cast head | Width of head of larva in hibernaculum | Instar of larva in hibernaculum |
|---|---|---|---|---|---|
| .299 mm. | .388 mm. | 5th instar | .227 mm. | .299 mm. | 4th instar |
| Broken | .275 mm. | 4th " | Distorted | .356 mm. | 5th " |
| Broken | .291 mm. | 4th " | Distorted | .308 mm. | 4th " |
| .275 mm. | .340 mm. | 5th " | .291 mm. | .356 mm. | 5th " |
| Distorted | .332 mm. | 5th " | Broken | .356 mm. | 5th " |
| Distorted | .388 mm. | 5th " | .291 mm. | .372 mm. | 5th " |

*Overwintering Larvae.*—The larvae in Nova Scotia begin to appear upon the buds in most seasons during the latter part of April. In 1927 they were observed on the buds on April 30, but emergence had begun at least a few days previous. In 1929 the first larva was observed working its way into a bud on April 25 and by May 5 practically all had deserted the hibernacula. Compared with *Spilonota ocellana* D. & S. in this respect, *Recurvaria nanella* Hbn. begins to emerge some few days earlier, and the period over which emergence occurs is not so prolonged. On May 5, when the larvae of the latter insect were about all within the buds, only about one-half of the former had emerged.

The larvae of *Recurvaria nanella* Hbn. upon emerging in the spring enter the buds at the tips if they have sufficiently expanded, otherwise they work their way through or between the bud scales and are soon obscured from view. Frass, green at first but soon turning brown, is cast out at the point of entrance and held loosely on the outside of the bud by a few threads of silk. In the early spring this frass is the only indication that the buds are infested. After the buds open the leaves are tied and held together with silk, thus interfering with normal development. The enclosed larvae frequently roll an inside leaf to form a close-fitting tube, and thus protected feed by skeletonizing the leaves within reach. The infested buds, blossoms and leaves as they appear upon the trees are so similar to those infested with the larvae of *Spilonota ocellana* D. & S. that a determination is impossible without opening and exposing the larva within.

There is a period varying from 50 to 72 days from commencement of feeding in the spring until pupation. This is an average of 56 feeding days. During this time the larvae apparently, from the data available, moult either two or three times. They were difficult to rear in confinement and the data gathered and given in Table 4 contains many gaps, with the result that only a few larvae were followed over this period with all details regarding moults. However, it appears that those larvae which hibernate as fourth instar moult three times, while those hibernating as fifth instar only moult twice in the spring. This is further substantiated by the fact

TABLE 4.—REARING RECORDS OF OVERWINTERING LARVAE *Recurvaria nanella* HBN. ANNAPOLIS ROYAL, N.S., 1929

| Date larva emerged from hibernaculum | Date first moult | Date second moult | Date third moult | Date larva spinning | Date pupated | Length prepupal period | Date adult emerged | Length pupal period |
|---|---|---|---|---|---|---|---|---|
| April 28 | May 16 | June 10 | June 19 | June 28 | July 9 | 11 days | Aug. 2 | 24 days |
| April 30 | May 25 | June 10 | (Disappeared June 4) | | | | | |
| April 27 | | May 20 | June 4 | June 7 | June 19 | 12 days | July 16 | 27 days |
| April 30 | | | | June 7 | June 24 | 17 days | July 19 | 25 days |
| April 27 | | May 14 | May 25 | June 4 | June 26 | 22 days | July 23 | 27 days |
| May 3 | May 24 | June 17 | (Dead in vial June 19) | | | | | |
| April 30 | May 12 | May 24 | June 4 | June 11 | June 19 | 8 days | (adult failed to emerge) | |
| April 26 | | May 20 | June 4 | June 9 | June 19 | 10 days | July 14 | 25 days |
| May 1 | | May 22 | June 4 | June 11 | (Died on June 13) | | | |
| April 28 | May 10 | May 25 | | June 7 | June 24 | 17 days | July 17 | 23 days |
| April 30 | May 17 | May 25 | | June 11 | June 19 | 8 days | (adult failed to emerge) | |
| April 30 | May 17 | June 2 | | June 11 | June 19 | 8 days | (adult failed to emerge) | |
| April 26 | | | June 2 | June 11 | June 19 | 8 days | July 16 | 27 days |
| April 27 | | | June 1 | June 11 | June 24 | 13 days | July 16 | 22 days |
| April 27 | | | May 31 | June 11 | June 24 | 13 days | July 20 | 26 days |
| April 25 | | | May 30 | June 11 | June 24 | 13 days | July 17 | 23 days |

that many mature larvae gathered from outside were examined and head widths obtained, but in no instance were any of a sufficient width to be considered as an eighth instar. There is a pre-moult period lasting from two to six days when a delicate tube of silk is spun within which the larva is inclosed. At this time the larvae are inactive and quite helpless. After moulting they soon regain their former activity and feeding is resumed.

When mature the larvae desert the foliage and wander to limbs searching for suitable places to pupate. In a few instances they failed to desert the foliage, but pupated among the partly eaten leaves. A pupal case or cell of silk is spun and after a pre-pupal period of eight to as long as twenty-two days in some instances, the larvae change to pupa. The more advanced larvae begin to pupate about June 15 and for the following three weeks this transformation proceeds.

## DAMAGE

Early injury to the developing buds, and the tying of the leaves and blossoms together preventing normal development are the injuries to be expected from this insect. For pronounced injury to the buds the insect must be present in rather large numbers, and except in a few very small areas this has not been known to occur in the Annapolis Valley. Even individual infestations are, as a rule, patchy, that is, in one part of the orchard the insect becomes prominent while a short distance away in another portion but few are found. The worst infested trees in 1929 and 1930 presented a ragged and somewhat unhealthy appearance at the first of the season. After the larvae become mature, the trees soon overcome this deformity of foliage and take on their normal appearance. The amount of leaf tissue consumed by the tiny larvae previous to hibernating apparently is of slight importance. Side injury to the fruit in the autumn, so common with many budmoths, does not occur, as the larvae do not come into contact with the fruit due to their mining habit.

## PARASITES

Parasites were active during 1929 in all localities where this insect was found and were apparently quite effective in reducing their numbers. The parasites recovered included a braconid species and at least two species of ichneumon flies. Syrphid fly larvae were also observed attacking the larvae in the spring of the year. From many pupae collected in the orchard and kept in the insectary for adult emergence, neither moths or parasites emerged, and the writer has been unable to determine if this was due in any way to unfavourable conditions at the insectary preventing adult emergence or if parasites were present and these were adversely affected as well.

## DESCRIPTION OF STAGES, RECURVARIA NANELLA HBN.

*Egg.*—Length .356 to .421 mm., width .210 to .259 mm. The egg when first laid is elongate, oval, not curved, rounded at ends and shining yellow in colour. Before hatching the egg at the micropylar end becomes slightly flattened with a number of minute projections which radiate longitudinally as fine pebbled ridges. These ridges may extend for practically the entire length of the egg, but more frequently only one-third to three-quarters of this distance. The colour becomes duller as the embryo develops and a dull dark area finally appears at the micropylar end due to the colour of the developing head capsule of the larva.

### LARVA

*First instar.*—Average width of head .129 mm. Total length of body .864 mm. Head pale brown, mouth parts slightly lighter than head, ocellar area black, setae short, fine and pale. Prothoracic shield dusky. Body pale yellow, including feet and prolegs. When viewed from above the caudal margin of each abdominal segment is whitish in colour; tubercles not distinguishable, setae short, fine and pale, anal plate chocolate brown.

*Second instar.*—Average width of head .178 mm. Total length of body 1.194 mm. Head black, not piceous, shining, ocellar area black; epistoma lighter than head, mandibles blackish; prothoracic shield dark olive green, slightly mottled. Body pale orange with a slight velvety appearance; feet and anal plate olive green, the latter somewhat mottled; spiracles difficult to discern.

*Third instar.*—Average width of head .243 mm. Total length of body 2.058 mm. Larva similar in appearance to previous instar except slightly darker in colour.

*Fourth instar.*—Average width of head .291 mm. Total length of body 2.593 mm. Head markings as previous instar. Prothoracic shield dark brown to black. Body a pale shade of brown ochre, with a decided velvety appearance; a small dark area on thorax equal distance from pro-shield and thoracic spiracle; spiracles very small, circular, and slightly produced; tubercles wanting, the short fine pale setae arising directly from the body wall, with a dusky circle at base; feet olive green, pale at joints; prolegs of the body colour with a narrow dusky band encircling the base; anal prolegs with a dusky area on dorso-lateral surface. When hibernating in this instar the larvae are contracted to less than 2 mm. in length.

*Fifth instar.*—Average width of head .356 mm. Total length of body 2.75 to 3.12 mm. The appearance of the larva in this instar is much the same as in the previous one.

*Sixth instar.*—Average width of head .455 mm. Total length of body 3.92 to 4.50 mm. Head markings are the same as in previous two instars. The body colour is a light shade of brown, slightly mottled with a velvety appearance. The tubercles are slightly produced, of the body colour. At the base of the setae is a small circle of darker colour than body. Chitinized areas of tubercles on abdominal segments 9 and 10 small and slightly darker than body. There are two in-curved hooks on each side of the anal opening; anal plate, as in all preceding instars, is a darker brown than the body surface.

*Seventh instar.*—Average width of head .567 mm. Total length of body 5.15 to 7.50 mm. Head black, epistoma lighter, brown; mandibles black; ocellar area black with transparent lenses; setae pale or rusty; short and fine. Body colour brown-ochre when first moulted; this colour is usually replaced with green or frequently a brick-red colour and it is not uncommon to find a mottling of these two colours. The larvae largely

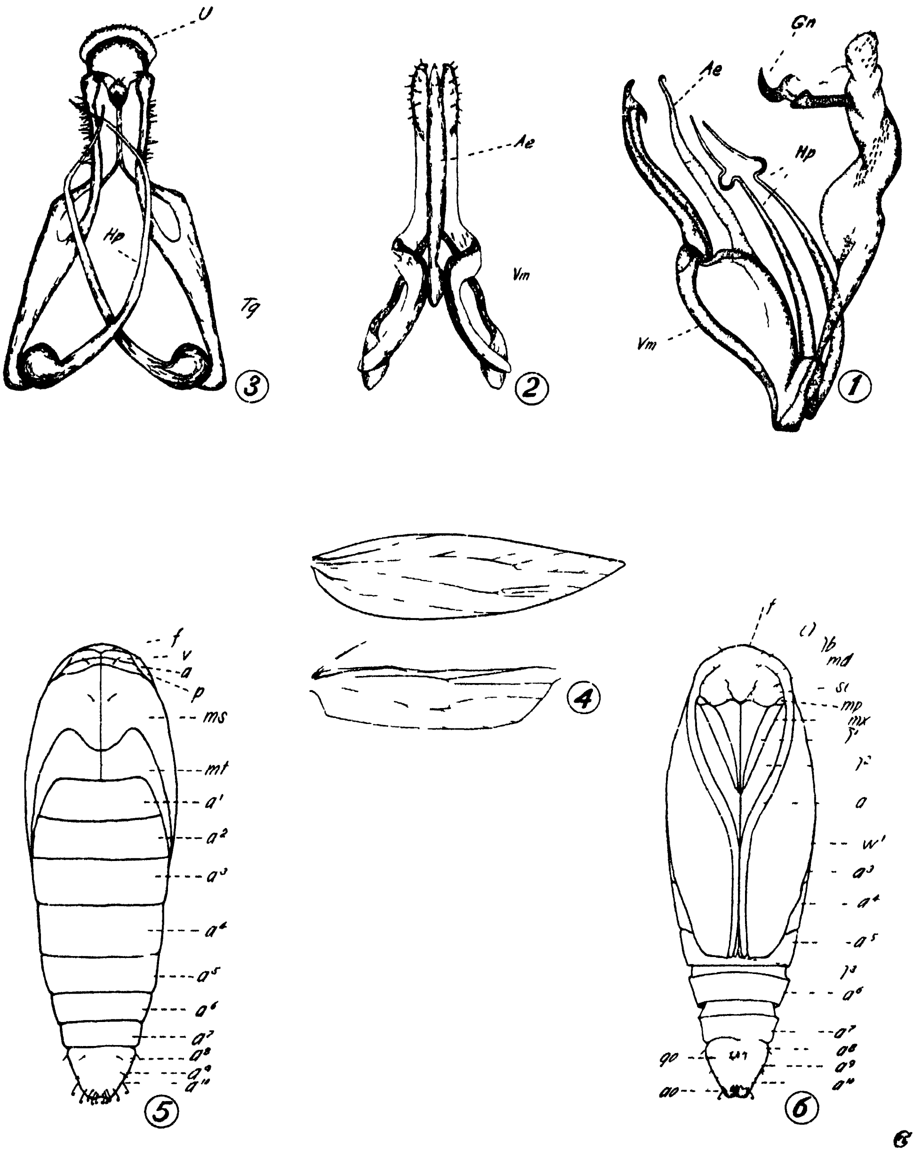

Plate 1.

LESSER BUDMOTH, *Recurvaria nanella* HBN.

1. Lateral view of male genitalia.
2. Ventral view of vinculum and aedoeagus.
3. Ventral view of tegumen and harpes.
4. Venation of wings of moth.
5. Pupa, dorsal view.
6. Pupa, ventral view.

Explanation of symbols applied to Genitalia—

*Ae*—aedoeagus.
*Gn*—gnathos.
*Hp*—harpe.
*Tg*—tegumen.
*U*—uncus.
*Vm*—vinculum.

Explanation of symbols applied to Pupa—

*a*—antenna.
*a*, 1 to 10—abdominal segments.
*ao*—anal opening.
*cl*—clypeus.
*f*—front.
*go*—genital opening.
*lb*—labrum.
$l^1$—prothoracic leg.
$l^2$—mesothoracic leg.
$l^3$—metathoracic leg.
*md*—mandible.
*mp*—maxillary palpus.
$w^1$—mesothorax wing.
*ms*—mesothorax.
*mt*—metathorax.
*mx*—maxilla.
*p*—prothorax.
*se*—sculptured eye-piece.
*v*—vertex.

PLATE 2

1 Apple leaves showing mines caused by the young larvae previous to hibernating
2 Apple leaves injured and tied together by the larvae after hibernation
3 Winter hibernaculum in axil of leaf bud
4 Pupae enclosed within the white cocoons on under surface of rough bark

lose their velvety appearance in this instar. Tubercles slightly produced, of the body colour; setae as previous instar, the circle at base now changed to colour of body; feet olive green, pale at joints; prolegs colour of surrounding body surface, the dark markings at base of prolegs very faint or wanting. This applies as well to the dark markings on thorax and abdominal segments 9 and 10. Anal plate colour of body in contrast to a chocolate brown in all previous instars. The mature larvae vary from 7.5 to 9 5 mm. in length.

### PUPA

The pupa is golden brown, segment 10 dark brown or black; pupal eyes either golden brown or black; clypeus, labrum and mandibles distinct; labial palpi entirely overlaid and concealed by the maxillae; antennae reaching to tip of wings; wings reaching to region of caudal margin fifth abdominal segment; spiracles small but distinct on segments 2 and 7; female genital opening a short dark slit, confluent with segments 8 and 9, no adjacent elevations; male genital opening on segment 9, a dark slit with slight elevations; anal opening in both sexes a dark slit slightly depressed on extreme rounded end of segment 10; cremaster wanting; across dorsum and continuing slightly on venter is an irregular row of slender bristles curved at tips about midway on segment 10, approximately 12 in number.

### ADULT

The adult moths of *Recurvaria nanella* Hbn. have a wing expanse of 11.5 to 12.5 mm. and in colour are a mixture of grey and black. A technical description by Busck of *Recurvaria crataegella* which is a synonym of *Recurvaria nanella*, is given in Proc. U.S. Nat. Mus. V, 25, p. 811, 1903. In the male genitalia the harpes, which are rounded, tapering organs, vary, in that some have a sharp twist or curve as figured in lateral view Plate 1, while in other individuals the harpes are only singly curved as shown in Figure 3 of the same plate.

## RESUME

NOTES SUR LE PETIT PIQUE-BOUTON, *Recurvaria Nanella* HBN. F. C. Gilliatt, Laboratoire fédéral d'entomologie, Annapolis Royal, N.-E.

Ce petit pique-bouton est un insecte européen qui a été signalé pour la première fois en Nouvelle-Ecosse en 1915. Il se nourrit du feuillage du pommier et l'on dit qu'il s'attaque également à d'autres arbres fruitiers aux Etats-Unis. Cet insecte peut très bien être confondu dans le verger avec le pique-bouton ocellé. On ne considère pas que ce soit un fléau sérieux pour le moment, mais il pourrait très bien le devenir s'il augmentait d'une façon excessive. Les papillons font leur apparition vers la fin de juillet. Les œufs sont pondus sur le dessous des feuilles. Ils éclosent en août et les jeunes larves se nourrissent des feuilles qu'elles minent. Après plusieurs mues, en septembre elles quittent les feuilles et se transportent sur les branches extérieures, où elles passent l'hiver dans des refuges soyeux, couverts de fientes, sous les écailles des vieux bourgeons et l'écorce détachée. Au printemps les larves paraissent sur les boutons vers la fin d'avril et produisent un effet typique de pique-bouton sur le feuillage. Lorsqu'elles ont toute leur taille, elles se transforment en chrysalides, principalement dans les crevasses de l'écorce, vers la fin de juin, et sortent sous forme de papillons vers la fin de juillet.

# QUANTITATIVE METHODS IN THE STUDY OF FOREST INSECTS[1]

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The various methods of studying forest insects referred to in this paper are essentially sampling methods, and some of them are quantitative in the broad sense of the term only. They may be conveniently divided into two principal groups: general population studies, and special studies of individual species or groups of species. The following is a concise account of some of the outstanding contributions in this field of research selected from the literature, and also of some experiments made by the author in the course of a study of the maple leaf-cutter, *Paraclemensia acerifoliella* Fitch.

## GENERAL POPULATION STUDIES

Very few general population studies have been made in the forest up to the present time. They are aptly referred to as animal community studies and are the work of ecologists rather than forest entomologists. Shelford and Sanders' *Quantitative and Seasonal Study of a Pine Dune Animal Community* (*9*) published in 1922 probably furnished the impetus and the inspiration for most of the work done subsequently on the animal communities of different types of forests. As such, it commands special attention both in respect to methods used and results obtained. The observations were made in 1914 in the dune region at the south end of Lake Michigan. The locality was a pine hollow in which jack pine was the dominant species. The method of collecting is described by the authors as follows: "The work was confined entirely to a study of quantity and of the correlation of local, especially vertical, animal distribution with temperature and evaporation. Collections were made and temperature and evaporation recorded in each of the levels commonly recognized, viz., ground, herbs, shrubs, and trees, between July 1 and August 30. This was done regularly every four or five days from all the levels at about 8.30 a.m. In addition, during two full days, the observations and collections were made in the various levels at intervals of four hours between 4.30 a.m. and 8.30 p.m. The ground collections were made where there were only scattered short-stemmed herbs. An actual count was made by forcing the open end of a bucket 25 cm. in diameter into the soil. By pouring a small quantity of a mixture of chloroform and gasoline through an opening in the inverted bottom, all the animals on the ground under the bucket were killed. It was difficult to see small insects such as aphids in the light soil. By using a fine sieve it was possible to obtain many which otherwise would have escaped observation. The other collections were obtained by making four strokes at each level with a close cotton net on a ring 30 cm. in diameter, with a handle 70 cm. long. To reduce the collections made with the bucket and net to the same value, sweeping with the net was followed in the same type of vegetation by bucket counting.

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[1] Paper delivered at the Fifth Pacific Science Congress, Vancouver, B.C., June 1-14, 1933.

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It was found with a number of trials that *three* sweeps of the net yield essentially the same number of animals from the vegetation as one bucket counting. Three strokes with the net equal approximately .022 cubic meter of average denseness; four strokes equal .029 cubic meter."

In their summary the authors point out the difficulties inherent to a census of this kind, the seasonal variations in numbers, the variations due to physical conditions, the inward migration of animals breeding in adjacent areas and the upward and downward migrations at different periods of the day. They also state unequivocally that, "The accessibility of animals varies with conditions and makes collections with nets, etc., variable."

In 1924, Weese (*13*) published his *Animal Ecology of an Illinois Elm-maple Forest.* His method of sampling was fundamentally the same as that used by Sanders and Shelford. The unit area for his samples in the soil and leaf strata was 2 feet square. In the herb and shrub strata he adopted 10 short sweeps of the net. The net used was 30 cm. in diameter and each sweep about one meter in length; he calculated that 10 such sweeps included approximately the volume of vegetation above the unit area. No samples were taken in the tree stratum. The observations covered the period of one year and led the author to present certain correlations between fluctuations in the animal population and changes in environmental conditions.

This is the first large-scale attempt at a study of an animal community on land made in America and it contains much interesting information on stratal and seasonal abundance, inward and outward migration, seasonal succession, and the reactions and the rate of development of animals in gradients of environmental factors.

Two years later a comparison of the animal communities of coniferous and deciduous forests was published in the Illinois Biological Monographs by I. H. Blake (*2*). It contains an account of three studies of the synecology of land animals, the animal ecology of the upper slopes of Mount Ktaadn, the animal ecology of Maine pine-hemlock forest and the animal ecology of a deciduous forest in winter. With minor modifications, the methods used by Blake were practically the same as those of Weese and Shelford. A supplementary study published by Blake in 1931 (*3*) and an independent investigation by Smith (*11*) of the animal communities of the same deciduous forest as that studied by Weese and Blake in Illinois present no special interest from the standpoint of technique and methods.

Another important contribution to the quantitative study of animal communities in the forest is that by Bird (*1*). Certain minor changes in the method of sampling adopted by Bird are worth mentioning. The method was "essentially the same as that used by King (*7*) in his study of the prairie and early successional stages toward the aspen forest at Saskatoon, Saskatchewan." This method presents several refinements of the methods used by the authors previously mentioned. The time for making the collections was set at an early morning hour, at a period of minimum activity of the insects, thus insuring more accurate and possibly more uniform results. Such samples would, of course, not be suitable for the study of daily variations in stratal distribution but were well adapted for the investigation of seasonal succession. Three to five sweeps of the net were used according to the density of the population. At the same time a sample was taken from the herb and surface strata by means of a metal cylinder 30 inches high and 14.13 inches in diameter. This cylinder was equipped with an iron band, 8 inches wide, sliding freely but closely over the outside of the cylinder. The place where a collection was to be made was approached quietly, and the cylinder was dropped open end downwards. The metal band was then forced a few inches into the ground and ether was poured into the cylinder through a hole at the top. After sufficient time had elapsed to anesthetize the insects, the cylinder was removed leaving the iron band in the ground. The insects found in the debris were gathered and, with the band still in the ground a soil sample was taken to a depth of 2 inches. A soil washer with two screens was used to separate the animals from the earth. It should be noted that the diameter of the metal cylinder 14.13 inches was chosen because the area of the circle enclosed represents 1/30,000 of an acre or 1/100,000 of an hectare. This measure greatly facilitates the calculation of the total population for any desired area.

In the work of all the above mentioned authors such an imposing array of interesting data is presented that little doubt can be entertained as to the validity of either the method used or the results obtained. In 1928, using similar methods, the author attempted a study of the animal communities of a maple-beech forest in the vicinity of Ottawa. Such striking variations and deficiencies appeared in our samples that it was necessary to forego the complete analysis of the data.

## Special Population Studies

A large number of special population studies of a quantitative nature have been made by forest entomologists in the course of the regular performance of their duties. Nevertheless very little definite information with regard to the methods employed by the various investigators is available. This is particularly the case so far as the work of American forest entomologists is concerned, and is perhaps due to a kind of subconscious feeling on the part of the investigator that a detailed description of methods used on any special problem would probably be of little value with a view to its application to projects of another kind.

Whilst it is undoubtedly true that in formulating a method of study the particular nature and needs of a situation must be taken into account, it is equally certain that nearly all investigations have so many characteristics in common that the details of the methods used in a special study may be of great suggestive value in planning the work to be done on a similar or even a quite different type of problem. Among the European workers who have given considerable attention to the publication of methods in the study of special insect populations, we find Seitner in Austria, I. Trägårdh in Sweden, Z. S. Golovjanko and A. Iljinsky in Ukrania, and Unio Saalas in Finland. The work of these investigators will now be reviewed and a brief description will be given of some methods of sampling used by the author in studying the fluctuations in the larval population of *Paraclemensia acerifoliella* Fitch.

Since the mode of life of the insect studied largely dictates the technique of sampling to be employed, boring and leaf-feeding insects will be treated under separate headings.

## A. QUANTITATIVE METHODS OF STUDYING BORING INSECTS

### *Seitner's Method of analysing bark-beetle populations*

Logically as well as chronologically Seitner's (*10*) method of studying the fluctuations in the population of *Ips typographus* should probably be regarded as the pioneer work in the quantitative analysis of bark-beetle populations. This method will not be discussed here because the fundamental principles underlying it are evolved and perfected in various directions in the experiments of the other European workers described in the succeeding paragraphs.

### *Trägrådh's methods of studying the distribution and succession of species*

At the International Congress at Zürich in 1926 Trägårdh (*12*) presented a paper in which he outlines a system of determining the relative economic importance of boring insects by an analysis of the selective tendencies exhibited by individual species as to the area attacked and also of the succession of the various species involved in the attack. Three principal methods are advocated: (a) Trap trees cut at monthly intervals during an entire year; (b) Analysis of dead or dying trees; (c) Sample plots. Trägårdh's principal contribution lies in his insistence on the necessity of making a thorough and complete analysis of entire trees, not simply of small sections of a tree, in his methods of representing graphically the results of analyses and in pointing out the practical value of such studies. The paper is too well known to require further comments.

### *Golovjanko's method of estimating infestations of the pine bark-beetle Myělophilus minor Hart*

In his investigations of forests infested by bark-beetles, Golovjanko (*4*) used two methods, a rapid method, and a more thorough and detailed one. Nothing need be said about the first as it does not differ essentially from the ordinary preliminary survey usually made before control projects are attempted. The second method offers several points of interest as to the mode of procedure both in the collection of data and in their analysis.

A standing tree, which it is proposed to analyse, is marked near the ground with four marks corresponding to the four cardinal points. The tree is felled and divided longitudinally by means of lines drawn on the bark into four sectors corresponding to the marks previously placed at the bottom. Then it is cut transversely into sections one meter long. The logs or sections are numbered consecutively from the base upward and the numbers are entered on the analysis sheet with notes indicating to which region of the tree each section belongs, namely, the region of thick bark, the region of transition, the region of thin bark and the crown region. Then the circumference at the middle of each log is measured in centimeters. The number of centimeters in such a measurement is equal to the number of square decimeters in the superficies of the side of the log. Next the bark is carefully removed and an exact count is made of the beetle families present. This is accomplished by counting either the entrance tunnels or the nuptial chambers and in polygamous species the number of egg tunnels. In counting the latter the base of the egg tunnels only is used to prevent duplication arising from the presence of parts of egg tunnels extending into the adjoining tree section. These data can be represented in a graph showing the successive meter lengths on the horizontal and the number of families on the vertical axis. This can be done either for the whole tree or for each sector and in the same graph the regions of the trunk can be indicated. Such a graph shows at a glance the distribution of various species in the different parts of the tree as well as the density of attack in any one area. (Fallen trees or trap trees are divided into sectors but not into meter lengths, each sector is analyzed as a whole. The sectors represent the upper, lower and lateral areas of the trunk.)

In the case of *Myelophilus minor* the curves of relative density of attack in the various meter lengths showed that the number of beetle families decreased toward the top of the tree. Two possible reasons for this decrease advanced by Golovjanko are that either the conditions for attack were less favourable in the upper part or that the decrease in numbers was due to the decrease in the diameter of the trunk. Apparently he does not consider the possibility of both these factors operating simultaneously. Hence he effects the exclusion of the second factor by determining the density of attack in terms of the average number of families per square decimeter. The data so obtained can then also be expressed in curves showing measures of length on the horizontal and measures of density on the vertical axis. Upon comparing such curves with curves of the number of families per meter length, it was found that, in the case of some insects *Ips acuminatus* for instance, the total number of beetle families decreases toward the top of the tree but that the relative density of attack increases. This proves that this particular species finds its optimum living conditions in the upper part of the tree.

For convenience in the construction of formulae Golovjanko devised a system of symbols representing all the important factors included in his study:

b—Average density of attack, *i.e.*, average number of families per square decimeter.

d—Average number of larval tunnels per family.

f—Per cent of larvae successfully completing their development.

l—Average number of families producing no young beetles at all.

c—Average number of exit holes (young beetles) per family.

p—Production, *i.e.*, average number of exit holes per square decimeter.

From a careful evaluation of these factors in his study of *M. minor* Golovjanko arrived at the following conclusions:

1. A decrease in the number of families means a decrease in the density of attack ("b").
2. A decrease in "b" is followed by (1) an increase in "d", the number of larval tunnels; (2) an increase in "f", the percentage of larvae successfully completing their development; (3) a decrease in "l", average number of families without progeny; (4) an increase in "c", the number of young beetles per family.

Golovjanko contends that only one factor production ("p") is independent of density of attack ("b") and that the more favourable the environment the greater will be the number of young beetles per family provided the density of attack ("b") be the same. These conclusions apply only to *Myelophilus minor* and to the particular experiments from which the data were derived.

The following generalizations, which the author offers merely as likely working theories in the study of *M. minor*, are also proposed by him:

1. In pines which are identical as to conditions of temperature and susceptibility to attack, the value of "p" is practically a constant.

2. When "p" is a constant $\frac{c}{c_1} = \frac{b_1}{b}$; in other words the density of attack is inversely proportional to the average number of young beetles per family.

3. In a series of cases the ratio $\frac{c}{c_1}$ was found more closely proportional to $\frac{d^2}{d_1^2}$ than to $\frac{d}{d_1}$, from which we obtain

$$d_1 = \frac{d}{\sqrt{\frac{c}{c_1}}}.$$

Hence, if we know the value of d for one area, we can calculate the same value ($d_1$) for another area. This formula however is not applicable except when $\frac{d^2}{c}$ = constant. A statistical analysis of the data shows that the variations of the value $\frac{d^2}{c}$ are not significant enough to affect the relations expressed by the formula. Golovjanko applied the above described method in testing the efficiency of trap trees as a control measure and arrived at some definite conclusions which, however, are outside of the scope of the present paper.

In 1928, A. Iljinsky using the method proposed by Golovjanko, analysed two lots of pines representing respectively 361 meters and 256 meters of tree superficies attacked by *Myelophilus minor*. This analysis produced the following results: For the entire 617 meters the number of beetle families was 82,054; the number of young beetles 310,136; and for the first 361 meters the larval tunnels totalled 852,893.

For each meter the following values were determined or calculated:

"A"—Number of beetle families per meter.

"M"—Number of larval tunnels per meter.

"O"—Number of exit holes (young beetles) per meter.

"q"—Superficies of each meter section expressed in square decimeters.

"b"—Density of attack $= \frac{A}{q}$.

"d"—Average number of larval tunnels per family $= \frac{M}{A}$.

"c"—Average number of young beetles per family $= \frac{O}{A}$.

"p"—Average number of young beetles per dcm.$^2$ $= \frac{O}{q}$.

"e"—Average number of larval tunnels per dcm.$^2$ $= \frac{M}{q}$.

"f"—Percentage of larvae completing their development $= \frac{100c}{d}$.

"l"—Percentage of beetle families producing no young beetles at all and

"k"—Percentage of families not having any larval tunnels at all.

These last two factors are determined by actual counts.

It is readily seen that $p = bc$ and $e = bd$.

The next step consisted in classifying all meter lengths according to density of attack, determining the arithmetical mean for each class and the corresponding arithmetical mean for all other values. The correlation between the averages so obtained was then calculated. On the ground of these calculations Iljinsky constructs a number of formulae which, as they apply only to this particular experiment, cannot be thoroughly understood unless the tabulated data on which they are based be presented in full. He states very definitely that generalized formulae could only be proposed as the result of experiments conducted over a number of years.

In his general conclusions, Iljinsky differs from Golovjanko on only one point, namely, the independence of production ("p") from the density of attack ("b"). He shows conclusively that the density of attack is in itself a factor affecting the favourableness of the environment. Golovjanko's method and its elaboration by Iljinsky undoubtedly contain numerous suggestions which should be of considerable value in the study of bark-beetle populations in general.

### *Saalas' method of line or strip surveys in the study of the degree of infestation by forest insects*

Saalas' (*8*) method of estimating populations is principally intended for use in the study of extensive areas infested by a number of species of boring beetles. In the sixteen forests examined by this method, the total length of the survey strips was approximately 28 kilometers. The strips were two meters in width and along their entire length every tree, living or dead, standing or fallen, and every stump were examined carefully. Notes were made of the diameter of the trees, the forest type, etc. A scale showing five degrees of infestation was devised.

I. One set of tunnels or a few scattered sets.
II. Distinctly less than half of the tree (or part of tree) covered with sets of tunnels.
III. Half the tree (or part of tree) covered with tunnels.
IV. Distinctly more than half of the tree (or part of tree) covered.
V. Nearly the entire area of tree (or part of tree) covered with tunnels.

By the expression "part of tree" in the above scale must be understood that particular area which any particular insect attacks under normal conditions. For instance, in the case of *Pityogenes chalcographus*, if the degree of infestation assigned is V, this means that in a small tree with thin bark the entire area of the tree is covered with sets of tunnels, but when the tree is large only that part of the tree is completely covered with tunnels which has a thin bark, namely, the top of the trunk and the branches.

It is, of course, necessary to fell all standing trees for an examination of this kind and it is usually not difficult to assign the different trees to the degree class to which they properly belong. There is, however, some danger of overlooking trees belonging to class I.

The data obtained in the course of a survey are arranged in tables in such a manner as to give a clear picture of the conditions prevailing in the examined district. A number of such tables are shown in Dr. Saalas' paper. Only a small fraction of the first of these is reproduced here to give an idea of the system used in tabulating (Table 1).

TABLE 1.—STANDING DEAD SPRUCES

| Species | Degree of infestation | DBH. in cm. | | | | | | | | Totals |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 7–10 | 11–15 | 16–20 | 21–25 | 26–30 | 31–35 | 36–40 | 41–45 | |
| | | % of trees infested | | | | | | | | |
| *Hylurgops palliatus* | 0 | 100 | 100 | 33 | 50 | 33 | 33 | 17 | | 41 |
| | II | | | | | | | 33 | 100 | 9 |
| | III | | | | 20 | | | 17 | | 9 |
| | IV | | | 67 | 30 | 67 | 67 | 33 | | 41 |
| *Polygraphus* sp. | 0 | | 100 | 33 | 70 | 67 | 100 | 83 | | 66 |
| | I | | | | | 33 | | | | 6 |
| | II | | | 33 | 10 | | | 17 | 100 | 13 |
| | III | | | 34 | 10 | | | | | 6 |
| | IV | 50 | | | 10 | | | | | 6 |
| | V | 50 | | | | | | | | 3 |
| *Crypturgus hispidulus* | 0 | 100 | 100 | 100 | 100 | 83 | 100 | 100 | 100 | 97 |
| | I | | | | | 17 | | | | 3 |
| *Xyloterus lineatus* | 0 | 100 | 100 | 100 | 40 | 33 | 33 | 17 | 100 | 47 |
| | III | | | | 30 | 33 | | 17 | | 19 |
| | IV | | | | 20 | 17 | 33 | 33 | | 19 |
| | V | | | | 10 | 17 | 34 | 33 | | 15 |

This table explains itself; one sees at a glance that *Crypturgus hispidulus* is of rare occurrence, that all the other species shown were quite common, that one-third of the trees with DBH of 36–40 cm. were heavily infested (V) with *Xyloterus lineatus*, etc.

## B. QUANTITATIVE METHODS OF STUDYING DEFOLIATORS

The quantitative study of defoliating insects presents many difficulties not encountered among the boring species. With the exception of the leaf-miners, they are free-living insects, many of them migrate over considerable distances, their distribution on the trees is often very uneven especially in moderate or light infestations, and many, moreover, live in the most inaccessible parts of the trees where any attempt at collecting them in the ordinary manner creates a disturbance sufficient to invalidate the results of the sampling. For these and other reasons it has been the time-honoured custom to make the population studies of leaf-feeders during the resting (prepupal and pupal) stages, particularly if these insects come to the ground to complete their transformations. Since there are almost as many methods of accomplishing this task as there are investigators, it would be impossible to weigh the merits of the individual systems, and as most of them are quite limited in scope little would be gained from such a review. Probably one of the most interesting and far-reaching methods described in the literature is that used by A. Iljinsky (*6*) in the study of *Dendrolimus pini* L. Its main features will, therefore, be outlined below. It is quite evident that a population study conducted along these lines may furnish most excellent data upon which to base a prognostication of the probable general increase or decrease in numbers of a certain species and may serve as a guide in planning practical control measures. Nevertheless, it fails to give an insight into the numerous agencies at work throughout the entire life-cycle of the species in the rise and fall of insect infestations. To this end, it becomes necessary to study the vicissitudes to which the species is subjected from the moment of oviposition to the adult emergence of the next generation. As far as we have been able to determine very few such continuous investigations have been attempted in a quantitative manner in the realm of forest entomology. During the years 1928–1930 the author undertook such a study on the maple leaf-cutter population of a sugar-grove in the vicinity of Ottawa.

### *Iljinsky's method of estimating the larval population of Dendrolimus pini on the ground*

The principal interest in this method attaches to the system employed in obtaining the required samples.

At first preliminary tests were made to ascertain the true distribution of the overwintering larvae in the debris. In a number of sample plots strips one-half meter wide were laid out in such a manner as to join the base of one tree to the next. All the trees in a plot were included in the experiment. The strips were then divided into meter lengths and the projection of the overhanging crowns was marked on the strip. For each meter length, *i.e.*, each half square meter, the number of larvae present in the litter was counted. Three test plots, containing 63 strips laid out between 61 trees, were examined. The strips varied in length from 1 to 26 meters. Tables were constructed with the strips arranged in ascending order according to their total length and the individual half square meter samples classified according to their distance from the trunk. The average number of larvae for each sample was then entered in its proper place. To give a better idea of this arrangement a small part of such a table is reproduced here (Table 2).

An analysis of the tabulated data showed that the greatest number of overwintering larvae congregated under the periphery of the crown. On the basis of this knowledge Iljinsky decided that to obtain a fair estimate of the population in his more extensive surveys it would be sufficient to count the larvae present at a distance of 2, 3, 4 and 5 meters in strips 4 × 0.5 meters located on that side of the tree on which the radius of the

TABLE 2.—AVERAGE NUMBER OF LARVAE PER 0.5 $M^2$ SAMPLE

| Length of strips in meters | Distance of Samples from the Base of the Tree | | | | | | | | | | | | | Frequency or number of strips |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | Etc. | |
| 1 | 0 5 | | | | | | | | | | | | | 2 |
| 2 | 6.0 | 3 | | | | | | | | | | | | 2 |
| 3 | 9.0 | 23 | 3 | | | | | | | | | | | 9 |
| 4 | 7.0 | 34 | 41 | 7 | | | | | | | | | | 7 |
| 5 | 6.0 | 60 | 98 | 35 | 5 | | | | | | | | | 8 |
| 6 | 23.0 | 42 | 76 | 70 | 32 | 7 | | | | | | | | 8 |
| 7 | 16.0 | 51 | 55 | 44 | 71 | 30 | 14 | | | | | | | 5 |
| 8 | 13.0 | 30 | 15 | 8 | 20 | 32 | 22 | 5 | | | | | | 1 |
| 9 | 5.0 | 18 | 27 | 27 | 28 | 26 | 24 | 9 | 1 | | | | | 4 |
| 10 | 7.0 | 16 | 29 | 24 | 14 | 16 | 24 | 17 | 13 | 1 | | | | 5 |

crown was the greatest. In discussing the merits of this system he states, among other things, that there is but little danger of overestimation since many larvae wander far beyond the periphery of the crown in search of hibernating quarters.

For the final estimate, it is necessary to calculate the number of larvae in relation to the area of the projection of the crown. This is done by multiplying the number of square meters in the projection by half the number of larvae in the two square meter sample. The calculated number of larvae per crown projection area approximated quite closely the numbers obtained from actual counts as may be seen from Table 3.

TABLE 3.—COMPARISON BETWEEN ACTUAL AND CALCULATED NUMBER OF LARVAE

| Tree | Crown area meters$^2$ | Number of larvae in sample 2 sq. meters | Calculated number of larvae in crown area | Actual number of larvae in crown area |
|---|---|---|---|---|
| A | 14.1 | 182 | 1283 | 1184 |
| B | 5.0 | 213 | 535 | 245 |
| C | 13.6 | 188 | 1278 | 1199 |
| D | 19.6 | 245 | 2391 | 1372 |
| E | 8.2 | 254 | 1041 | 517 |
| Averages | | 216 | 1305 | 903 |

Before studying a forest, a general survey was made and the infested areas were mapped, the estimated intensity of each area being noted on the survey lines. Then the samples (4 × 0.5 meters) were taken on the survey lines in the different areas as follows: in the heavily infested areas at intervals of about 40 meters; in lightly infested areas at intervals of about 100–200 meters and, where the limits of the infestation were to be determined, at intervals of 20 meters.

The larval counts were made by eight women, working eight hours per day. They were able to count over some 14 to 24 samples daily, depending on the number of larvae present.

As the investigation progressed, the synopsis of the data reduced to averages per square meter was charted on a map by means of iso-lines showing the relative density of the population in the different areas. One type of line was used to delimit areas with an average of more than 100 larvae; another type, those with an average 50 to 100 larvae; and a third type, those with less than 50 larvae. Such a map makes it possible not only to appraise the conditions prevailing in the area studied, but also to estimate quite accurately what may be expected in the adjoining area.

### *A method of studying the progressive reduction in numbers during the active larval stages of Paraclemensia acerifoliella Fitch*

*Paraclemensia acerifoliella*, a member of the family *Incurvariidae*, is a very common species which feeds on maple and, in some seasons, becomes very destructive in the sugar maple groves of Eastern Canada and the northeastern United States. Its general habits have been described by Fitch and by Herrick but these papers lack in several details which have a direct bearing on the present discussion, and it will, therefore, be necessary to preface this study of methods with a few words on some points in the life-history of the species.

Normally, the moths begin to fly during the last ten days of May; the peak of emergence is reached during the last days of May or the first days of June, and thereafter adult emergence continues at a rapidly decreasing rate until about June 15. The sex ratio is about 50 : 50. The female punctures the lower epidermis of the leaf and makes a small pocket in which a single egg is deposited. Upon dissection it was found that the ovaries contained from 100 to 120 eggs but it is probable that only about one-half or, at best, three-fourths of these are laid. The period of incubation is from 12 to 20 days. The newly hatched larvae live in an irregular serpentine mine between the upper and lower epidermis of the leaves. At the end of about six days the first moult takes place. The second stage larva continues to feed inside of the mine for a period of from three to five days, after which it cuts the first case. This case is made of a small rounded piece of the upper epidermis and a larger similar piece of the lower epidermis of the leaf cut out of the end of the mine. From that time on, the larva wanders about freely over the leaf surface carrying its case, the larger piece protecting the back of the larva and the smaller piece partly covering the lower part of the body. Wherever the larva settles to feed, the case is lightly attached to the surface of the leaf by means of silken strands. In the act of feeding, the front part of the body is protruded from beneath the upper cover and the leaf surface is skeletonized in a small circle around the periphery of the case. When most or all of the food within easy reach becomes consumed, the larva moves its case to a new location and the whole operation is repeated; the total number of feeding places varies somewhat from individual to individual. The second moult takes place within this first case, and the third stage larva continues to feed inside of it for a short time (1 to 4 days). Then the larva settles down in a chosen spot and proceeds to cut out of the leaf a new and larger cover for its case. When the cover is completed the larva moves the case away and continues its feeding operations as previously. The case now consists of the two epidermal layers cut out of the mine and of the newly cut piece of leaf and in this paper will be referred to as the "second case". The small hole at the end of the mine where the first case was cut is referred to as the "first cut" whilst the hole left in the leaf where the new lid was cut will be called the "second cut". As time goes on, more cases, or rather new covers, are cut to accommodate the growing larva. All the lārvae have six stages. Some of them cut five cases whilst others cut six. In a complete, normal life-history the last cover is of exactly the same dimensions as the larger piece of the case within which the larva was feeding up to that time. Feeding is no longer possible as the case is completely closed and inside of it the larva drops to the ground to pupate beneath the litter. A considerable percentage of the larvae do not cut this last fifth or sixth case and are quite able to pupate and hibernate successfully in their unfinished houses, provided they have completed the sixth stage of their development before dropping from the trees.

Briefly then, each completed larval life-history leaves the following traces on the surface of the leaves: (a) 1 mine; (b) 5 or 6 cuts gradually increasing in size; (c) a varying number of skeletonized feeding places corresponding in diameter to the size of case from which the feeding was done. The first case is cut by the second stage larva, the second case by the third stage larva and so forth, and the fifth case and also the sixth case are cut by the sixth stage larva. Although the sixth case appears to be supernumerary it should be remembered that a high percentage of the larvae construct such a case. Furthermore, since the various cases correspond quite closely to the different larval stages and since, to the practiced eye, it is a simple matter to distinguish the successive cases by their dimensions, it seems quite legitimate to use these cases as an index of larval development rather than the actual stages which cannot be identified except by tedious microscopic measurements. This has been our practice in the field experiments connected with this study.

In the fall of 1927, the attention of the Division of Forest Insects, Dominion Entomological Branch, was called to a severe outbreak of the maple leaf-cutter in a farm woodlot not far from Ottawa. Subsequent events proved that the infestation had reached its peak during the summer of 1927. There was a marked decline in 1928 and 1929 and the remnants of the population died out in 1930. The investigations were begun in the spring of 1928. During that year much time was devoted to the devising of appropriate methods, the analysis of the physical conditions of the habitat and to a general study of the life-history and habits of the insect. Much information was obtained, but it was not until the spring of 1929 that a systematic study of the causes attending the very noticeable reduction in population was attempted. It is needless to state that the experience gained during the previous season formed the basis of all the experiments undertaken in 1929 and 1930. Quantitative methods were used in all phases of the study: adult emergence, oviposition, embryonal development, larval development, reduction of the larval population and its causes, pupation and hibernation, fall and winter mortality, etc. In addition to these an elaborate system of physical measurements was maintained in operation at different points and different levels. All these experiments did not produce equally satisfactory results but, on the whole, a considerable measure of success was attained.

Only one of these experiments will be treated here in as concise a manner as possible, namely, the study of the progressive reduction of the larval population.

A method of simple or random sampling was used in the analysis of the larval population present on the trees. When the study was commenced in the spring of 1929, the infestation had dwindled to a notable extent, and, whilst practically all the trees were infested to a degree, the distribution of the insects on the individual trees had become quite spotty. Moreover, the relative density of the population varied in different parts of the grove. It was difficult therefore to establish a sufficiently uniform universe from which the samples were to be taken. After some deliberation it was finally decided to lay out a strip of plots 50′ × 50′ running diagonally from north to south through the grove. This strip would contain all the levels (290′ to 320′ above sea-level), all the different soil conditions, the principal conditions of exposure to wind and sunshine, a representative sample of the vegetation and a good cross-section of the infestation. The strip was 1550 feet in length and was divided into 31 plots. All the trees in it were numbered consecutively from north to south and an exact map showing their position and the projections of the crowns, was drawn. There were 237 trees in the plot representing all the principal species in the grove in the following proportions: maple 66%; beech 21%; ironwood 8%; elm 2%; linden 3%.

It was decided further that, the weather permitting, one sample would be taken every second day throughout the season under the following conditions and restrictions:

(a) 86 trees, selected as being particularly suitable for the work were to be used as the source of the component units of a sample.

(b) From each of these trees a twig, approximately 1½ feet in length, was to be cut at a height of from about 8 to 15 feet from the ground, this twig to be taken from the tip of a branch showing a fair degree of infestation.

The individual unit was analysed in the field and the following points were recorded in the note books under the number of the tree from which the twig was taken:

(a) Number of mines in which the larva had died.

(b) Number of mines from which the larva had cut its first case.

(c) Total number of mines.

(d) Number of 1st, 2nd, 3rd, etc., cases present containing living larvae.

(e) Number and kind of cases present containing dead larvae (cause of death if known).

(f) Number of feeding places.

Not until the experiment had been in progress for some time was it realized that very unfortunately the number of "cuts" had been omitted from this record. This constituted a very serious mistake which could not be remedied afterward. Whilst this omission affected the significance of the final results, it does not invalidate the method of sampling as such, as will be shown later.

In all, 42 samples were taken between June 25 and September 18. The first of these samples had to be discarded owing to defects arising from inexperience. This leaves 41 samples between June 27 and September 18. Tables containing the complete set of data are too large for publication; we must therefore restrict ourselves to the final averages obtained from an analysis of the material at hand.

Average number of mines per sample, 123.

Average number of first cases based on five observations at the peak of frequency, 104.

Average number of second cases on same basis as above, 66.

Average number of third cases, 53.

Average number of fourth cases, 47.

Average number of fifth cases, 19.

(Sixth cases are rarely found as they drop from the trees as soon as constructed; it may be assumed that a large percentage of the larvae found in fifth cases cut a sixth case.)

If we assume that all larvae in the fifth and sixth cases and about 50% of the larvae which constructed fourth cases only successfully completed their development, the average number of survivors amounts to 32, or 26% of the larvae hatched from the egg.

As a check against the above experiment three station trees were analysed periodically. On each of these trees, 500 leaves, on branches satisfying the same general conditions as those set for the regular sampling, were marked with consecutive numbers. The numbers were written in India ink on the upper surface of the leaves, a fine camel's hair brush being used for the purpose.

The population present on the marked leaves was analysed once a week, the same system of notes being used as in the analysis of the plots with the one important difference that, in this case, the number and size of cuts was recorded as well as the number of the cases. The distance between tree A and tree B was 240 feet, and between tree B and tree C 150 feet; the infestation on tree B was somewhat heavier than on the other two trees. In the final comparison the averages for the three trees were computed. This gave the following figures:

Average number of mines, 147.

Average number of first cases, 120.

Average number of second cases, 76.

Average number of third cases, 53.

Average number of fourth cases, 46.

Average number of fifth cases, 24.

Final survival was calculated as for the previous experiment at 24%.

The difference, therefore. between the figures representing survival in these two independent experiments amounts to only 2%. Furthermore, the progressive stages of this reduction of the population parallel each other very closely as can be seen by juxtaposing the figures obtained in each analysis:

| | Sample plots | Station trees | | Sample plots | Station trees |
|---|---|---|---|---|---|
| Mines | 123 | 147 | Third cases | 53 | 53 |
| First cases | 104 | 120 | Fourth cases | 47 | 46 |
| Second cases | 66 | 76 | Fifth cases | 19 | 24 |

These figures do not represent the true reduction in the population, because the number of cases found on the trees gives no indication of the entire number of cases actually cut. The figures given are merely adduced to show that the results of the two experiments with respect to a common factor are strictly comparable. This correspondence between the two experiments holds equally well in respect to a number of other phenomena, such as the dates of first appearance and of maximum frequency for each larval stage.

For the reasons already stated, it was impossible to use the data derived from the sample plot study to determine the true decrease in the number of larvae. This, however, could be easily done for the station trees and since the experiments were comparable in all other respects, it may be reasonably supposed that they would agree on this point also. The figures showing the absolute reduction present a very different picture from those showing the proportional reduction. They are based on the average number of mines and cuts counted on the station trees, and are as follows:

| | | | |
|---|---|---|---|
| Mines | 147 | Fourth cuts | 70 |
| First cuts | 120 | Fifth cuts | 65 |
| Second cuts | 96 | Sixth cuts | 8 |
| Third cuts | 79 | | |

Assuming again that 50% of the larvae not advancing beyond the fourth case may be reckoned among the survivals as well as all the larvae in the fifth and sixth cases we find:

| | |
|---|---|
| Number of larvae in the fourth case | 70 |
| Less larvae progressing to fifth and sixth cases | 65 |
| Number of larvae not progressing beyond fourth case | 5 |
| 50% of 5 (roughly) | 2 |
| Number of larvae in fifth case only (65 − 8) | 57 |
| Number of larvae in sixth case | 8 |
| Total of survivors | 67 |

$$\text{Per cent survival } \frac{67 \times 100}{147} = 45\%$$

All the figures gives thus far are for the year 1929. In 1930, we met with a new and entirely different set of conditions. The fall of 1929 and the early spring of 1930 were marked by a very heavy mortality among the prepupal larvae and the pupae on the ground. As a result, the spring population was confined to a small area of the grove and to a few trees within this area. The sample plots used during the previous season were practically free from infestation and were no longer suitable for further studies. We were forced to use the station tree method in our work. The material for study was exceedingly scarce. Twenty trees were used; the individual samples varied considerably in size and contained in all 1000 numbered leaves. Although the results of this study have only an indirect bearing on the principal object of this paper, they present considerable interest inasmuch as they show the process of reduction of a severe infestation through its last stages. A summary of the principal features of the experiment is contained in the Table 4.

TABLE 4.—PROGRESSIVE STAGES IN THE REDUCTION OF THE POPULATION OF *P. acerfoliella*
1930

| | | | | | |
|---|---|---|---|---|---|
| EGGS: | Hatched | 789 | MINES: | Complete | 641 |
| | Unhatched | 1135 | | Incomplete | 148 |
| | Total | 1924 | | Total | 789 |

| Dates of analyses | Cuts | | | | | | Cases present | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 1 | 2 | 3 | 4 | 5 | 6 |
| June 22 | 14 | | | | | | 14 | | | | | |
| 25 | 253 | | | | | | 253 | | | | | |
| 28 | 393 | | | | | | 391 | | | | | |
| July 1 | 544 | 3 | | | | | 517 | 1 | | | | |
| 4 | 607 | 37 | | | | | 517 | 41 | | | | |
| 7 | 633 | 135 | | | | | 422 | 135 | | | | |
| 10 | 639 | 261 | | | | | 277 | 264 | | | | |
| 15 | 641 | 400 | | | | | 134 | 356 | | | | |
| 18 | | 446 | | | | | 72 | 361 | | | | |
| 21 | | 446 | 7 | | | | 38 | 312 | 6 | | | |
| 24 | | 468 | 56 | | | | 16 | 247 | 52 | | | |
| 30 | | 471 | 119 | | | | 6 | 130 | 85 | | | |
| Aug. 6 | | 473 | 167 | 5 | | | 2 | 48 | 104 | 3 | | |
| 13 | | 475 | 174 | 19 | | | | 19 | 89 | 17 | | |
| 20 | | | 175 | 53 | | | | 3 | 54 | 47 | | |
| 27 | | | 176 | 61 | 2 | | | | 18 | 41 | 3 | |
| Sept. 3 | | | | | 8 | | | | 4 | 18 | 9 | |
| 10 | | | | | 9 | | | | | 9 | 7 | |
| 17 | | | | | | 2 | | | | | 1 | 1 |

Both the "sample plot" method and the "station tree" method seem to be well adapted to the study of the larval stages of *P. acerifoliella*. It should be remembered that this insect is sedentary in its habits. Many individuals complete their entire larval cycle on a single leaf; the average number of leaves visited by the larva in its migrations is about four and usually these are all close together. Migration being a factor of minor importance, the question of effective sampling is greatly simplified. The results obtained from the repeated analyses of stationary samples are not subject to the same amount of variation as those derived from sample plot studies but the labour involved is exceedingly tedious and requires vastly more time. For this reason it can be applied only to restricted areas and does not permit the investigation of many different conditions which may or may not affect the rate of development and the multiplication of the species.

The sample plot method, on the other hand, provided it be carefully planned, gives results which, for all practical purposes, are equally conclusive; it is more interesting, less laborious and has, above all, the decided advantage of being applicable to larger areas and a greater number of varying conditions. To give an idea of the variation met with in sampling according to this method, a statistical test was applied to the data collected in the sample plots in 1929. In the case of *P. acerifoliella*, the most suitable element for this test is the number of mines per sample. It marks the beginning of the larval life, can be determined throughout the season and, if the sampling is done properly in a well defined, uniform universe, should be fairly constant. In the tables constructed for the test, the 41 samples taken in 1929 were arranged according to the number of completed mines in 10 classes with intervals of 10 units per class. By using the mid-value of the class as a measure of variation we obtain the results shown in Table 5. In Table 6 the mean of the actual variations within the class limits was used and we arrive at practically the same conclusions.

TABLE 5.—MEASURE OF DISPERSION IN THE NUMBER OF MINES PER SAMPLE IN THE SAMPLE PLOT STUDIES*

Arithmetic mean = 104

| Classes | f | m | x | $x^2$ | $fx^2$ |
|---|---|---|---|---|---|
| 60 - 69 | 2 | 65 | 39 | 1521 | 3042 |
| 70 - 79 | 5 | 75 | 29 | 841 | 4205 |
| 80 - 89 | 4 | 85 | 14 | 196 | 784 |
| 90 - 99 | 5 | 95 | 9 | 81 | 405 |
| 100 - 109 | 9 | 105 | 1 | 1 | 9 |
| 110 - 119 | 7 | 115 | 11 | 121 | 847 |
| 120 - 129 | 3 | 125 | 21 | 441 | 1323 |
| 130 - 139 | 2 | 135 | 31 | 961 | 1922 |
| 140 - 149 | 2 | 145 | 41 | 1681 | 3362 |
| 150 - 159 | 2 | 155 | 51 | 2601 | 5202 |
| Totals | 41 | | | | 21101 |

Standard deviation = $\sqrt{\frac{\Sigma fx^2}{n-1}} = \pm 22.96$

Probable error = $.6745\sigma = \pm 15.47$

TABLE 6.

Arithmetic mean = 104

| Classes | f | m | x | $x^2$ | $fx^2$ |
|---|---|---|---|---|---|
| 60 - 69 | 2 | 65.50 | 38.50 | 1482.25 | 2964.50 |
| 70 - 79 | 5 | 75.60 | 28.40 | 806.56 | 4032.80 |
| 80 - 89 | 4 | 84.50 | 19.50 | 380.25 | 1521.00 |
| 90 - 99 | 5 | 94.50 | 9.50 | 90.25 | 451.25 |
| 100 - 109 | 9 | 101.89 | 2.11 | 4.45 | 40.05 |
| 110 - 119 | 7 | 113.45 | 9.45 | 89.29 | 625.03 |
| 120 - 129 | 3 | 127.00 | 23.00 | 529.00 | 1587.00 |
| 130 - 139 | 2 | 131.00 | 27.00 | 729.00 | 1458.00 |
| 140 - 149 | 2 | 142.00 | 38.00 | 1444.00 | 2888.00 |
| 150 - 159 | 2 | 155.50 | 51.50 | 2652.25 | 5304.50 |
| Totals | 41 | | | | 20872.13 |

Standard deviation = $\sqrt{\frac{\Sigma fx^2}{n-1}} = \pm 22.8$

Probable error = $.6745\sigma = \pm 15{\cdot}37$

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*Only completed mines, that is to say mines from which first cases had been cut are included in Tables 5 and 6.

These tables show that if, as is customary for between 30 and 200 observations, we place the limit of rejection at four times the probable error, all the variations satisfy the requirements of normal probability. The final results of the two systems of calculation differ so very little that it seems advisable to use the first method only as it is somewhat simpler than the second.

In conclusion, may it be said that in the study of the maple leaf-cutter the above described methods produced very satisfactory results not only in determining the rate of decrease in numbers from stage to stage and from year to year, but in the analysis of many other biological phenomena. We have reason to believe that these methods, with the necessary modifications to adapt them to the individual problem, would produce good results in the investigation of other leaf-feeding insects with somewhat similar habits, such as leaf-miners and insects which feed gregariously.

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## RESUME

MÉTHODES QUANTITATIVES POUR L'ÉTUDE DES INSECTES DES FORÊTS. J. J. De Gryse, Division de l'Entomologie, Ministère de l'Agriculture, Ottawa, Ont.

Les différentes méthodes employées pour l'étude des insectes des forêts, et dont il est question dans ce travail, sont essentiellement des méthodes d'échantillonnage et certaines d'entre elles ne sont quantitatives que dans la signification la plus large de ce terme. On peut commodément les diviser en deux groupes principaux: Etudes de la population générale, et études spéciales d'espèces, prises séparément, ou de groupes d'espèces. Il ne s'est fait jusqu'ici que très peu d'études de la population générale. C'est plutôt là un travail pour les écologistes que pour les entomologistes des forêts. On les a justement nommées des études de la communauté animale.

Les entomologistes forestiers ont fait un grand nombre d'études spéciales de population d'une nature quantitative, mais il n'existe encore que très peu de renseignements précis sur les méthodes employées par les différents investigateurs. Parmi les chercheurs européens qui ont donné beaucoup d'attention à la publication des méthodes employées dans l'étude des populations spéciales d'insectes: nous trouvons Seitner en Autriche, I. Tragardh en Suède, Z. S. Golovjanko et A. Iljinsky en Ukraine et Unio Saalas en Finlande. Les travaux de ces chercheurs sont passés en revue, et à la fin de l'ouvrage, certaines méthodes d'échantillonnage pour l'étude des fluctuations de la population larvaire de *Paraclemensia acerifoliella* Fitch. sont décrites quelque peu en détail. La méthode de "parcelles d'échantillons" et celle "d'arbre de station" paraissent bien convenir à l'étude de cet insecte dont les habitudes sont très sédentaires. Beaucoup d'individus complètent tout leur cycle larvaire sur une seule feuille; le nombre moyen de feuilles visitées par la larve dans ses migrations est d'environ quatre et généralement toutes ces feuilles sont près l'une de l'autre. Comme la migration est un facteur d'importance secondaire, la question de l'échantillonnage est grandement simplifiée de ce fait.

# FIELD EXPERIMENTS ON THE PREVENTION OF CEREAL RUSTS BY SULPHUR DUSTING (1930-1932)[1]

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## INTRODUCTION

Experiments reported by Kightlinger (*10*), in 1924, demonstrated the possibility of controlling cereal rusts by dusting growing plants with sulphur. In 1925 Bailey and Greaney (*1*) in Manitoba, Lambert and Stakman (*12*) in Minnesota, and Kightlinger and Whetzel (*11*) in New York, obtained very effective control of rusts on cereals with sulphur dust. The Manitoba field results were very satisfactory and stimulated further interest in the practical possibility of preventing cereal rusts by dusting. The results of dusting experiments in Manitoba from 1926 to 1929, inclusive, have been reported by Bailey and Greaney (*2*) and Greaney (*7*). The present paper deals with the results of field experiments made in 1930, 1931, and 1932, at Winnipeg, Manitoba, and is a further contribution to our knowledge concerning the prevention of cereal rusts by the use of dust fungicides.

## METHODS AND MATERIALS

Each year of the investigation a small field of summer-fallowed clay loam soil was chosen for the experiments. The experimental field was planted to large blocks of Marquis wheat and Victory oats on May 10 and May 16, respectively. About a month after planting the blocks were divided into 1/400th acre plots. The plots were rectangular in shape and particularly suitable for hand-dusting and harvesting operations. Alleys and buffer strips of grain were left at the ends and sides of adjacent plots to serve as protection against dust drift. In 1930, 1931, and 1932, in order to insure a sufficient amount of rust infection, the grain was grown under conditions of artificially induced rust epidemics in conjunction with naturally occurring ones.

Dusting operations were commenced each year just as soon as rust appeared in the district, but not necessarily in the experimental plots. Thereafter, the plots were treated at regular intervals until the grain was beginning to ripen. Except where otherwise mentioned Kolodust, a colloidal sulphur dust, was used throughout the tests. The fungicides were applied by means of small hand-dusters which were checked at frequent intervals during the dusting season to insure reasonable accuracy and uniformity in the rate of application.

Final leaf rust readings, based on the scale of stem rust percentages adopted by the Office of Cereal Crops and Diseases, United States Department of Agriculture, were made when the leaves were still green; those for stem rust, just before the plants ripened.

The grain in the outside drill rows and at the end of each plot was removed by hand before harvest to minimize errors due to border effect.

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[1] Contribution No. 388 from the Division of Botany, Experimental Farms Branch, Department of Agriculture, Ottawa, Canada. Paper delivered before the Canadian Phytopathological Society at the World's Grain Exhibition and Conference, Regina, Sask., July 27, 1933.

[2] Plant Pathologist.

The yield results were then obtained by harvesting and threshing each plot separately. Weight per measured bushel was ascertained by bulking the threshed grain of each replicated series and weighing according to Canadian Grain Standards. The correct marketable grade of each treatment was determined by officials of the Western Grain Inspection Division, Winnipeg, Manitoba.

The present experiments were planned with consideration of the intimate relation which must exist between the arrangement of the experiment and the statistical analysis of the data. The Latin Square plan of randomized experiment was used, and the analysis of variance method devised by Dr. R. A. Fisher was employed in analyzing the rust, grain quality and yield data. A complete discussion of the analysis of variance method is given by Fisher (*3*), and full details in the practical application of the method will be found in papers by Fisher and Wishart (*4*), Goulden (*5*, *6*), and Immer (*8*, *9*). The significance of the difference between the variance for dust treatments and the variance for error was determined by the $z$ test developed by Fisher (*3*). In the interpretation of the experimental results the 5% point (20 : 1 odds) is taken as a convenient minimum level of significance.

The standard error is the measure of variation used in this study. In comparing the differences observed between any two treatments, differences of less than three times their standard error are ascribed to chance; differences as great or greater than these are considered significant and ascribed to such dusting effects as the experiments were designed to examine.

## EXPERIMENTAL RESULTS

### OBSERVATIONS ON THE SEVERITY OF RUST EPIDEMICS

Destructive epidemics of stem rust of both wheat and oats (*Puccinia graminis* Pers.) occurred in 1930 at Winnipeg, Manitoba. In that year leaf rust of wheat (*Puccinia triticina* Erikss. and Henn.) was present, but it appeared later than stem rust and was much less severe. Crown rust of oats (*Puccinia coronata* var. *avenae* Erikss.) caused considerable damage in 1930.

Stem rust of wheat was much less destructive in 1931 than in 1930, while oat stem rust developed vigorously and reached epidemic proportions in 1931 in the experimental plots. In that year infestations of leaf rust of wheat and crown rust of oats were light and variable, so that the amount of damage caused by these diseases in 1931 was very slight.

Stem rust infection of both wheat and oats was lighter in 1932 than in the two previous years. Furthermore, the plants matured early and uniformly and escaped severe injury from these rusts. There was, however, an unusually heavy epidemic of leaf rust of wheat in 1932, at Winnipeg, and it was by far the most destructive wheat disease in that year. Light infections of crown rust occurred in the experimental plots in 1932.

In the final analysis of the results of each year rust percentages and yields of individual plots of each experiment were correlated. The significance of the correlation coefficients obtained was tested by the method given by Fisher (*3*). For zero order coefficients the following formula was used:

$$t = \frac{r}{\sqrt{1-r^2}} \cdot \sqrt{n^1-2} \quad ,$$

where $n^1$ is the number of pairs entering into the correlation. The correlation coefficients for the wheat and oat dusting experiments, together with their *t* values, are presented in Table 1.

TABLE 1.—CORRELATION COEFFICIENTS FOR RUST AND YIELD OF WHEAT AND OATS FROM RESULTS OF SULPHUR DUSTING EXPERIMENTS MADE IN 1930, 1931, AND 1932, AT WINNIPEG, MAN.

| Crop | Year | Correlation | Number of plots | Correlation coefficient | *t* |
|---|---|---|---|---|---|
| Wheat | 1930 | Stem rust and yield | 144 | 0.9379 | 32.3 |
| | 1931 | Stem rust and yield | 84 | 0.8037 | 12.2 |
| | 1932 | Stem rust and yield | 97 | 0.5342 | 6.1 |
| | 1932 | Leaf rust and yield | 99 | 0.7604 | 11.7 |
| Oats | 1930 | Crown rust and yield | 86 | 0.8972 | 18.6 |
| | 1930 | Stem rust and yield | 86 | 0.8860 | 17.5 |
| | 1931 | Stem rust and yield | 64 | 0.4949 | 4.9 |
| | 1932 | Stem rust and yield | 86 | 0.5831 | 6.5 |

Significant value of $t = 2.8$

The results in Table 1 show the relative seasonal severity and importance of rust epidemics in 1930, 1931 and 1932, at Winnipeg, Manitoba. Owing to light infestations of leaf rust of wheat in 1930 and 1931, and of crown rust of oats in 1931 and 1932, the effect of these diseases on yield could not be determined for those years.

## THE PREVENTION OF STEM RUST AND LEAF RUST OF WHEAT

The rates of sulphur dust used in the wheat dusting tests were 45, 30, and 15 pounds per acre at each application. The time intervals tested were 20, 15, 10, 5, and 2 days. Each year during the course of the investigation initial dust applications were made on July 13 when from 75 to 100% of the Marquis wheat plants were in head. Thereafter, the plants were dusted at regular intervals until the grain was beginning to ripen. The dusting period extended for 30 days in 1930, and for 36 days in 1931 and 1932.

The analysis of variance calculations for dust treatments and error, together with the *z* value and 5% point for each set of data analyzed, are given in Table 2. The variance in rust severity, weight per measured bushel of grain, and yield, due to dust treatments, is undoubtedly greater than the error variance, as the observed values of *z* exceed the 5% points. It is possible, therefore, to examine the individual treatment differences of each experiment in the light of their standard error. The results of the experiments, showing the effect of dusting on the severity of rust infection, and on the consequent yield and quality of Marquis wheat in 1930, 1931, and 1932, are given in Table 3 and presented graphically in Figure 1.

TABLE 2.—VARIANCE CALCULATIONS AND z TESTS. COMPARISON OF VARIANCE FOR RUST SEVERITY, WEIGHT PER MEASURED BUSHEL AND YIELD OF MARQUIS WHEAT, DUE TO VARIOUS SULPHUR DUST TRANSMENTS, WITH THAT FOR ERROR

| Year | Variable | Source of variance | Variance[1] | $z^2$ | 5% point |
|---|---|---|---|---|---|
| | | Stem and leaf rust of wheat: Per cent severity | | | |
| 1930 | Stem rust | Treatments<br>Error | 2939.03<br>54.96 | 1.9897 | 0.3136 |
| 1931 | Stem rust | Treatments<br>Error | 3712.77<br>61.54 | 2.0500 | 0.3384 |
| 1932 | Stem rust | Treatments<br>Error | 5557.07<br>24.60 | 2.7089 | 0.3484 |
| 1932 | Leaf rust | Treatments<br>Error | 6214.72<br>36.31 | 2.5713 | 0.3484 |
| | | Quality of grain: Weight per bushel in pounds | | | |
| 1930 | Grain quality | Treatments<br>Error | 836.97<br>11.02 | 2.1651 | 0.3136 |
| 1931 | Grain quality | Treatments<br>Error | 165.93<br>2.69 | 1.9603 | 0.3384 |
| 1932 | Grain quality | Treatments<br>Error | 30.02<br>0.60 | 1.9564 | 0.3484 |
| | | Yield of grain: Bushels per acre | | | |
| 1930 | Yield | Treatments<br>Error | 820.14<br>5.64 | 2.4898 | 0.3136 |
| 1931 | Yield | Treatments<br>Error | 24.47<br>5.85 | 0.7153 | 0.3384 |
| 1932 | Yield | Treatments<br>Error | 293.18<br>8.66 | 1.7608 | 0.3484 |

[1] Mean square or variance $(S.D.^2) = \frac{\text{Sums of squares}}{}$

[2] $z$ = One-half the difference between the natural logarithms of the two variances, or the difference between the natural logarithms of the standard errors (standard deviations).

The results in Table 3 show clearly that stem rust and leaf rust of wheat can be effectively prevented by dusting with sulphur. In every instance there were highly significant differences in both grain quality and yield between dusted and undusted plots. The results not only show that rusts cause great reductions in yield, but indicate also that grain quality is markedly affected by these diseases.

The amount of rust infection was directly associated with yield and grain quality. The results show that the degree of rust control, and consequent improvement in yield and grain quality, is directly proportional to the rate and frequency of dust application. In general, the interval between dust applications was a more important factor in determining the effectiveness of sulphur dust than was the rate of application. Each year

TABLE 3.—SUMMARY OF RESULTS. EFFECT OF DUSTING WITH SULPHUR ON THE AMOUNT OF RUST INFECTION, AND ON THE CONSEQUENT YIELD AND QUALITY OF MARQUIS WHEAT IN 1930, 1931, AND 1932, AT WINNIPEG, MANITOBA

| Year | Amount of sulphur per acre per application | 0 | 15 lbs. | | | | | 30 lbs. | | | | 45 lbs. | | | | General Mean | Standard Error |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Interval between dust applications in days | Check | 20 | 15 | 10 | 5 | 2 | 15 | 10 | 5 | 2 | 15 | 10 | 5 | 2 | | |
| 1930 | Total number of dust applications | 0 | 2 | 3 | 4 | 8 | 15 | 3 | 4 | 8 | — | 3 | 4 | 8 | — | | |
| 1931 | | 0 | — | 2 | 3 | 7 | 18 | 2 | 3 | 7 | 18 | — | 3 | 7 | — | | |
| 1932 | | 0 | — | — | — | 8 | 18 | 3 | 5 | 8 | 18 | — | 5 | 8 | 18 | | |
| | Stem rust and leaf rust: Per cent severity | | | | | | | | | | | | | | | | |
| 1930 | Stem rust | 95 | 88 | 81 | 60 | 28 | 23 | 77 | 43 | 8 | — | 74 | 32 | 5 | — | 51.4 | 2.14 |
| 1931 | Stem rust | 76 | — | 62 | 59 | 41 | 18 | 57 | 57 | 46 | 10 | — | 56 | 33 | — | 46.8 | 3.20 |
| 1932 | Stem rust | 70 | — | — | — | 27 | 4 | 55 | 39 | 19 | 3 | — | 36 | 11 | 1 | 26.5 | 1.57 |
| 1932 | Leaf rust | 75 | — | — | — | 34 | 6 | 57 | 50 | 26 | 3 | — | 42 | 20 | 2 | 31.5 | 1.90 |
| | Quality of grain: Weight per measured bushel Canadian grade | | | | | | | | | | | | | | | | |
| 1930 | Weight in pounds | 40 | 42 | 43 | 55 | 59 | 60 | 45 | 57 | 60 | — | 49 | 60 | 61 | — | 52.4 | 0.96 |
| | Grade | Feed | Feed | Feed | No. 4 | 1° | 1° | Feed | 3° | 1 Hard | — | No. 6 | 1° | 1 Hard | — | — | — |
| 1931 | Weight in pounds | 52 | — | 54 | 56 | 61 | 63 | 56 | 55 | 62 | 64 | — | 56 | 62 | — | 58.3 | 0.67 |
| | Grade | No. 5 | — | No. 4 | 3° | 1° | 1 Hard | 3° | 3° | 1 Hard | 1 Hard | — | No. 4 | 1 Hard | — | — | — |
| 1932 | Weight in pounds | 58 | — | — | — | 62 | 63 | 60 | 61 | 62 | 64 | — | 61 | 63 | 64 | 61.8 | 0.25 |
| | Grade | 2° | — | — | — | 1° | 1° | 1° | 1° | 1° | 1° | — | 1° | 1° | 1° | — | — |
| | Yield of grain: Bushels per acre | | | | | | | | | | | | | | | | |
| 1930 | Yield | 6.1 | 7.5 | 8.2 | 14.2 | 20.0 | 25.9 | 9.8 | 18.1 | 27.8 | — | 10.7 | 21.7 | 30.4 | — | 16.7 | 0.68 |
| | Per cent of Mean | 36.5 | 44.9 | 49.1 | 85.0 | 119.8 | 155.1 | 58.7 | 106.4 | 166.5 | — | 64.1 | 129.9 | 182.0 | — | 100.0 | 4.07 |
| 1931 | Yield | 9.4 | — | 11.4 | 12.0 | 17.3 | 22.2 | 12.5 | 12.3 | 18.3 | 22.8 | — | 13.0 | 18.9 | — | 15.4 | 0.99 |
| | Per cent of Mean | 61.0 | — | 74.0 | 77.9 | 112.3 | 144.2 | 81.2 | 79.9 | 118.8 | 148.0 | — | 84.4 | 122.7 | — | 100.0 | 6.42 |
| 1932 | Yield | 31.0 | — | — | — | 42.0 | 46.4 | 36.6 | 40.2 | 44.7 | 48.0 | — | 40.2 | 46.1 | 47.3 | 42.3 | 0.93 |
| | Per cent of Mean | 73.3 | — | — | — | 99.3 | 109.7 | 86.5 | 95.0 | 105.7 | 113.5 | — | 95.0 | 109.0 | 111.8 | 100.0 | 2.20 |

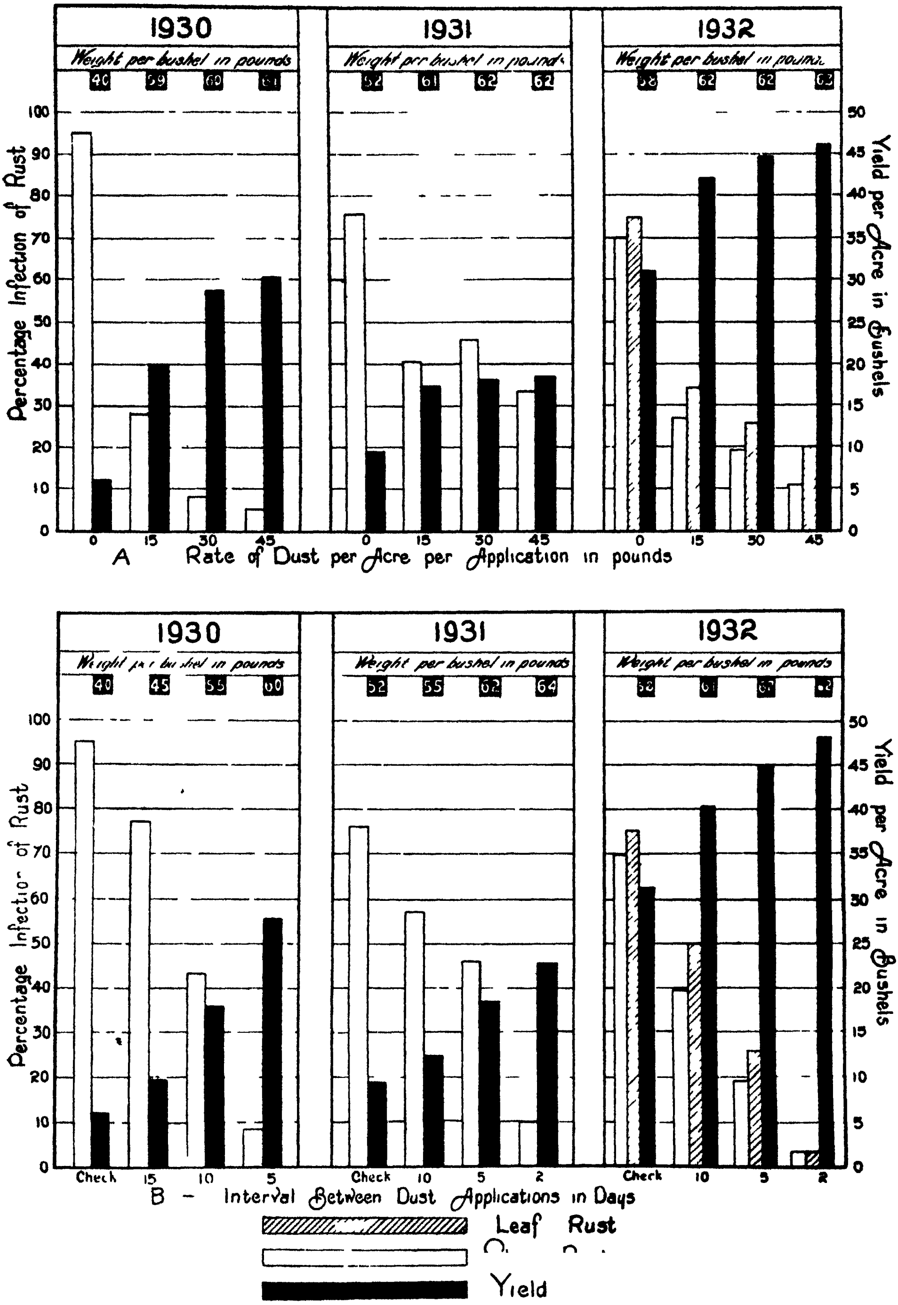

FIGURE 1. Results of sulphur dusting experiments for the prevention of stem rust and leaf rust of wheat in 1930, 1931, and 1932. Effect of rate and frequency of sulphur application on the severity of rust infection, and on the consequent yield and weight per measured bushel of grain. A. Results of dusting at different rates, and at five-day intervals. B. Results of dusting at different intervals, and at the rate of 30 pounds per acre per application.

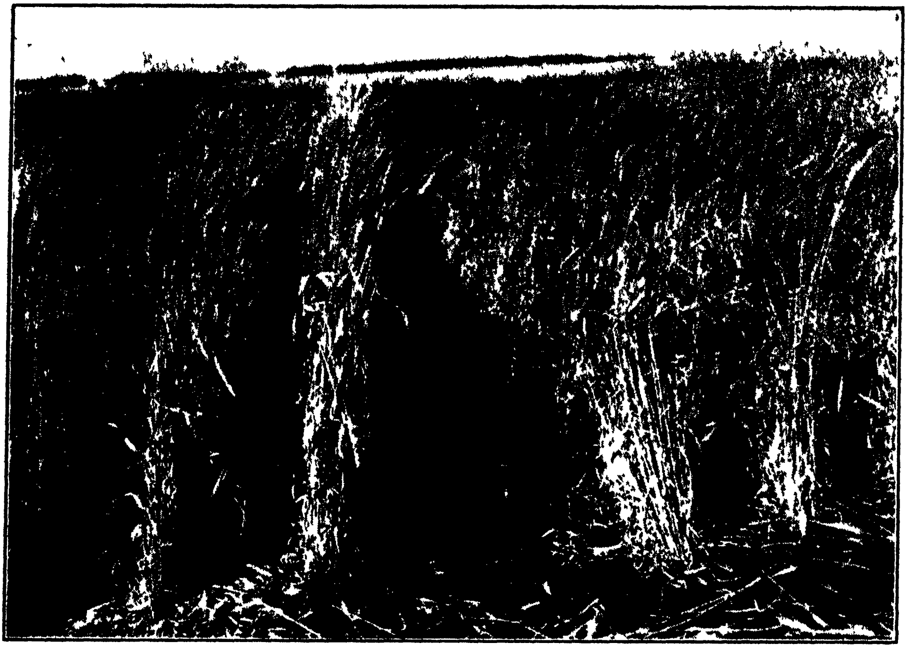

FIGURE 2. Plots of Marquis wheat at Winnipeg in 1930. Left: sulphur-dusted plot. Right: check plot, not dusted, showing the effect of severe stem rust attack.

of the investigation leaf rust and stem rust of wheat were almost completely prevented by applying sulphur dust at frequent intervals (2 and 5 days) from the time the wheat plants were in the late "boot" stage until the grain was beginning to ripen.

In 1930 the yield of Marquis wheat was increased 24.3 bushels or approximately 400% by dusting, even in the presence of severe infestations of stem rust. In that year eight dust applications raised the quality of grain from "Feed", weighing 40 pounds per bushel, to "1 Northern", weighing 61 pounds per bushel. In 1931 the yield was increased over 135% by dusting. By preventing leaf rust and stem rust of wheat in 1932, dusting increased the yield 63%. A photograph of dusted and undusted plots of Marquis wheat grown at Winnipeg in 1930, is shown in Figure 2.

## THE PREVENTION OF STEM RUST AND CROWN RUST OF OATS

The rates and frequencies of sulphur dust application tested in the oat dusting studies were identical with those used in the wheat experiments. In 1930 oat dusting was begun on July 16 and continued until August 22 (37 days). The dusting periods in 1931 and 1932 extended from July 12 to August 14 (32 days).

The analysis of variance calculations of rust severity, grain quality, and yield, are given in Table 4. The oat dusting schedules followed in 1930, 1931, and 1932, together with the results showing the effect of dusting on the amount of rust infection at harvest time, and on the consequent quality and yield of Victory oats, are given in Table 5 and presented graphically in Figure 3.

TABLE 4.—VARIANCE CALCULATIONS AND *z* TESTS. COMPARISON OF VARIANCE FOR RUST SEVERITY, WEIGHT PER MEASURED BUSHEL AND YIELD OF VICTORY OATS, DUE TO VARIOUS SULPHUR DUST TREATMENTS, WITH THAT FOR ERROR

Stem and crown rust of oats: Per cent severity

| Year | Variable | Source of variance | Variance | *z* | 5% point |
|---|---|---|---|---|---|
| 1930 | Stem rust | Treatments | 4494.78 | 2.1769 | 0.3484 |
| | | Error | 57.79 | | |
| 1930 | Crown rust | Treatments | 4969.38 | 2.3368 | 0.3484 |
| | | Error | 46.40 | | |
| 1931 | Stem rust | Treatments | 917.63 | 1.8244 | 0.4017 |
| | | Error | 23.88 | | |
| 1932 | Stem rust | Treatments | 3354.55 | 2.3625 | 0.3484 |
| | | Error | 29.76 | | |

Quality of grain: Weight per bushel in pounds

| | | | | | |
|---|---|---|---|---|---|
| 1930 | Grain quality | Treatments | 106.48 | 1.6467 | 0.3484 |
| | | Error | 2.40 | | |
| 1931 | Grain quality | Treatments | 94.28 | 2.0772 | 0.4017 |
| | | Error | 1.48 | | |
| 1932 | Grain quality | Treatments | 43.04 | 1.8518 | 0.3484 |
| | | Error | 1.06 | | |

Yield of grain: Bushels per acre

| | | | | | |
|---|---|---|---|---|---|
| 1930 | Yield | Treatments | 2049.15 | 1.7896 | 0.3484 |
| | | Error | 57.24 | | |
| 1931 | Yield | Treatments | 530.53 | 1.1321 | 0.4017 |
| | | Error | 53.82 | | |
| 1932 | Yield | Treatments | 76.04 | 1.0491 | 0.3484 |
| | | Error | 9.33 | | |

Each year during the course of the study crown rust and stem rust of oats were effectively prevented by dusting with sulphur. The effects of dusting were least with light, infrequent dustings, and greatest with heavy, frequent ones. In all the experiments the improvement in grain quality and yield was very closely associated with the degree of rust control.

Significant responses in yield were obtained from all the treatments. In 1930 the yield of Victory oats was increased 45.3 bushels per acre, or about 150%, and the weight per measured bushel of the grain was improved from 26 to 35 pounds by dusting. The increase in yield in 1931, due to rust control, was almost 100%, while an increase in yield of 15% resulted in 1932.

TABLE 5.—SUMMARY OF RESULTS.—EFFECT OF DUSTING WITH SULPHUR ON THE AMOUNT OF RUST INFECTION, AND ON THE CONSEQUENT YIELD AND QUALITY (WEIGHT PER BUSHEL) OF VICTORY OATS IN 1930, 1931, AND 1932, AT WINNIPEG, MANITOBA

| Year | Amount of sulphur per acre per application | 0 | 15 lbs. | | | | 30 lbs. | | | | 45 lbs. | | | | General Mean | Standard Error |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Interval between dust applications in days | Check | 15 | 10 | 5 | 2 | 15 | 10 | 5 | 2 | 15 | 10 | 5 | 2 | | |
| | Total number of dust applications | 0 | 3 | 4 | 8 | 18 | 3 | 4 | 8 | 18 | 3 | 4 | 8 | 18 | | |
| Stem rust and crown rust: Per cent severity | | | | | | | | | | | | | | | | |
| 1930 | Crown rust | 76 | 52 | 32 | 21 | 4 | — | 23 | 12 | 2 | 36 | 23 | — | — | 28.8 | 2.15 |
| 1930 | Stem rust | 62 | 53 | 27 | 12 | 3 | — | 10 | 3 | 1 | 30 | 17 | — | — | 21.8 | 2.40 |
| 1931 | Stem rust | 57 | — | 45 | 44 | 29 | 48 | 45 | 40 | 23 | — | — | — | — | 41.3 | 1.73 |
| 1932 | Stem rust | 57 | — | — | 21 | 6 | — | 35 | 17 | 3 | 40 | 33 | 11 | 1 | 22.4 | 1.72 |
| Quality of grain: Weight per measured bushel, Canadian grade | | | | | | | | | | | | | | | | |
| 1930 | Weight in pounds | 26 | 29 | 32 | 34 | 34 | — | 34 | 35 | 35 | 32 | 33 | — | — | 32.4 | 0.49 |
| | Grade | 2 Feed | 2 Feed | 1 Feed | 1 Feed | 1 Feed | — | 1 Feed | 1 Feed | 1 Feed | 1 Feed | 1 Feed | — | — | — | — |
| 1931 | Weight in pounds | 30 | — | 31 | 33 | 36 | 32 | 32 | 33 | 36 | — | — | — | — | 32 9 | 0.38 |
| | Grade | 2 Feed | — | 2 Feed | 2 Feed | 2 C.W. | 2 Feed | 2 Feed | 2 Feed | 2 C.W. | — | — | — | — | — | — |
| 1932 | Weight in pounds | 40 | — | — | 41 | 42 | — | 41 | 41 | 43 | 41 | 42 | 43 | 43 | 41.7 | 0.32 |
| | Grade | 2 C.W. | — | — | 2 C.W. | 2 C.W. | — | 2 C.W. | 2 C.W. | 2 C.W. | 2 C.W. | 2 C.W. | 2 C.W. | 2 C.W. | — | — |
| Yield of grain: Bushels per acre | | | | | | | | | | | | | | | | |
| 1930 | Yield | 29.5 | 37 9 | 53.5 | 58 1 | 71.8 | — | 62 9 | 64 8 | 74 8 | 54 8 | 60 9 | — | — | 56.9 | 2.39 |
| | Per cent of Mean | 51.8 | 66 6 | 94 0 | 102 1 | 126 2 | — | 110 5 | 113 9 | 131 5 | 96 3 | 107 0 | — | — | 100.0 | 4.20 |
| 1931 | Yield | 23 8 | — | 29 1 | 32 8 | 45 3 | 26 3 | 29 2 | 38 8 | 44 0 | — | — | — | — | 33.7 | 2.59 |
| | Per cent of Mean | 70.6 | — | 86 3 | 97 3 | 134 4 | 78 0 | 86 6 | 115 1 | 130 6 | — | — | — | — | 100.0 | 7.68 |
| 1932 | Yield | 56 4 | — | — | 62 5 | 63 7 | — | 61 4 | 62.1 | 64 9 | 61 6 | 62.5 | 65 6 | 64 0 | 62.5 | 0.97 |
| | Per cent of Mean | 90 2 | — | — | 100 0 | 101 9 | — | 98 2 | 99 4 | 103 8 | 98.6 | 100 0 | 105.0 | 102.4 | 100.0 | 1.55 |

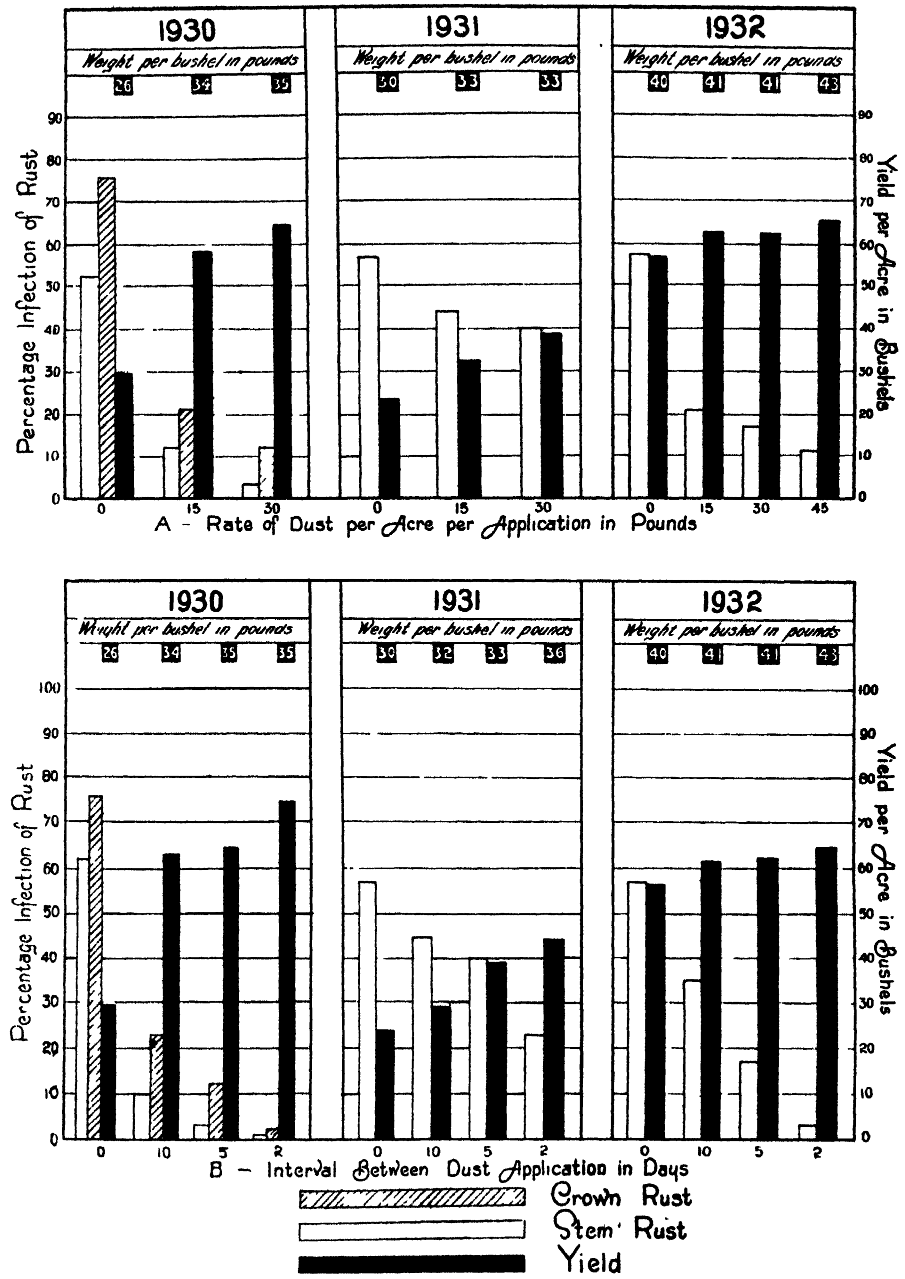

FIGURE 3. Results of sulphur dusting experiments for the prevention of stem rust and crown rust of oats in 1930, 1931, and 1932. Effect of rate and frequency of sulphur application on the severity of rust infection, and on the consequent yield and weight per measured bushel of grain. A. Results of dusting at different rates, and at five-day intervals. B. Results of dusting at different intervals, and at the rate of 30 pounds per acre per application.

In 1930, a severe rust year, the most effective rust control was achieved by applying sulphur at the rate of 30 pounds per acre at two-day intervals from July 16 to August 22. In 1931 and 1932, when stem rust was much less severe than in 1930, very effective rust control was achieved by 30-pound applications of dust at five-day intervals. From a practical viewpoint dusting at intervals of five days constitutes the most satisfactory dusting procedure. The three years' results clearly demonstrate the effectiveness and practical possibility of sulphur dusting for the control of oat rusts.

## FUNGICIDAL EFFECTIVENESS OF DIFFERENT SULPHUR DUSTS

The field testing of fungicides is an important phase of any plant disease control problem. It is usually difficult, however, to test all available fungicidal dusts in the field. In the present study adequate greenhouse tests were relied upon to eliminate all but the most promising dusts for the control of cereal rusts. From a large number of dusts, therefore, five commercial brands of sulphur dust were selected for field tests.[3]

A study of the relative value of these dusts in controlling stem rust and leaf rust of wheat was made in 1930, 1931, and 1932. The dusts were applied at the rate of 30 pounds per acre at each application, and the interval between dust applications was five days. The length of the dusting period varied in different years from 32 to 38 days.

The summarized results of the analysis of variance of per cent rust severity, weight per bushel, and yield, are given in Table 6. The experimental data of the three years' dusting tests, showing the amount of rust infection, and consequent yield and quality of the grain, are summarized in Table 7.

At harvest time in 1930, 1931, and 1932, a considerable amount of rust infection was found in the dusted plots. Unfortunately, owing to the rate and frequency of application used, none of the fungicides tested gave perfect rust control. The results in Table 7 show that, for the most part, differences in rust severity between various dust treatments were quite significant, since they exceeded three times the standard error. On the other hand, differences in yield between various dusts used in these experiments were not always beyond an amount which could easily be obtained by chance. In every instance, however, rust and yield differences observed between dusted and non-dusted plots of Marquis wheat were statistically significant.

Of the dusts tested Koppers dust was the most effective fungicide in 1930, while Kolodust was decidedly better than any of the others in 1931 and 1932. The reduced efficiency of Kolodust in 1930 was due to the age of the fungicide used. Sulfodust, a medium grade of sulphur dust, although it did not afford the plants as much protection as did some of the finer and more expensive dusts, gave very satisfactory control of rust in 1931 and 1932. It is possible that the cheaper grades of sulphur dust may prove effective and economic fungicides for the control of cereal rusts.

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[3] Kolodust and Sulfodust manufactured by Niagara Sprayer and Chemical Co., Middleport, N.Y.; Electric Sulphur by Stauffer Chemical Co., Houston, Texas, U.S.A.; and Koppers Dust and Koppers Lime-Dust prepared by Koppers Research Corporation, Pittsburgh, Pa., U.S.A.

TABLE 6.—VARIANCE CALCULATIONS AND $z$ TESTS. COMPARISON OF VARIANCE FOR RUST SEVERITY, WEIGHT PER MEASURED BUSHEL AND YIELD OF MARQUIS WHEAT, DUE TO VARIOUS DUST FUNGICIDES, WITH THAT FOR ERROR

Stem rust and leaf rust of wheat: Per cent severity

| Year | Variable | Source of variance | Variance | $z$ | 5% point |
|---|---|---|---|---|---|
| 1930 | Stem rust | Treatments | 2340.53 | 2.0920 | 0.3484 |
| | | Error | 34.26 | | |
| 1931 | Stem rust | Treatments | 729.16 | 1.2718 | 0.4046 |
| | | Error | 57.30 | | |
| 1932 | Stem rust | Treatments | 2296.30 | 1.6630 | 0.4017 |
| | | Error | 82.53 | | |
| 1932 | Leaf rust | Treatments | 2147.10 | 2.0034 | 0.4017 |
| | | Error | 39.06 | | |
| Quality of grain: Weight per measured bushel in pounds | | | | | |
| 1930 | Grain quality | Treatments | 150.41 | 1.4752 | 0.3484 |
| | | Error | 7.87 | | |
| 1931 | Grain quality | Treatments | 24.16 | 1.3389 | 0.4046 |
| | | Error | 1.66 | | |
| 1932 | Grain quality | Treatments | 25.74 | 2.1079 | 0.4017 |
| | | Error | 0.38 | | |
| Yield of grain: Bushels per acre | | | | | |
| 1930 | Yield | Treatments | 65.91 | 1.6468 | 0.3484 |
| | | Error | 3.35 | | |
| 1931 | Yield | Treatments | 21.72 | 0.6912 | 0.4046 |
| | | Error | 5.45 | | |
| 1932 | Yield | Treatments | 78.13 | 1.1678 | 0.4017 |
| | | Error | 7.56 | | |

## DISCUSSION AND CONCLUSIONS

The results of the present studies substantiate those obtained in Manitoba during the five years, 1925 to 1929, and clearly demonstrate the effectiveness of sulphur dusting for the control of cereal rusts. Leaf rust and stem rust of both wheat and oats were satisfactorily prevented in 1930, 1931, and 1932, even in the presence of severe epidemics. The data presented in this paper permit of a very accurate estimation of the amount of damage caused by cereal rusts under field conditions.

During the course of the investigation it was observed that frequent applications of sulphur dust to growing plants markedly prevented the development of wheat scab, black chaff of wheat, "smudge" of wheat, and some of the minor leaf and stem spotting diseases of both wheat and oats. As in previous studies (7) it was found that, although large amounts of sulphur were applied to the soil, no marked fertilizer effect occurred.

TABLE 7.—SUMMARY OF RESULTS. RELATIVE FUNGICIDAL EFFECTIVENESS OF FIVE BRANDS OF SULPHUR DUST. EFFECT OF DUSTING ON THE AMOUNT OF RUST INFECTION, AND ON THE CONSEQUENT YIELD AND QUALITY OF MARQUIS WHEAT IN 1930, 1931, AND 1932, AT WINNIPEG, MANITOBA

| Year | — | Kolodust | Electric sulphur | Koppers dust | Koppers lime dust | Sulfodust | Control (no dust) | General Mean | Standard Error |
|---|---|---|---|---|---|---|---|---|---|
| Stem rust and leaf rust of wheat: Per cent severity | | | | | | | | | |
| 1930 | Stem rust | 57 | 63 | 41 | 57 | 65 | 95 | 63.0 | 1.85 |
| 1931 | Stem rust | 35 | 45 | 31 | 37 | 45 | 76 | 44.9 | 2.39 |
| 1932 | Stem rust | 17 | 23 | 31 | 32 | 26 | 70 | 33.2 | 2.21 |
| 1932 | Leaf rust | 22 | 27 | 35 | 35 | 40 | 77 | 39.3 | 3.21 |
| Quality of grain: Weight per measured bushel, Canadian grade | | | | | | | | | |
| 1930 | Weight in pounds | 47 | 46 | 54 | 48 | 46 | 38 | 46.5 | 0.89 |
| | Grade | 6 | 6 | 5 | 6 | 6 | Feed | — | — |
| 1931 | Weight in pounds | 62 | 60 | 61 | 60 | 60 | 52 | 59.2 | 1.55 |
| | Grade | 1° | 1° | 1° | 1° | 1° | No. 5 | — | — |
| 1932 | Weight in pounds | 63 | 63 | 62 | 62 | 62 | 58 | 61.7 | 1.05 |
| | Grade | 1° | 1° | 1° | 1° | 1° | 2° | — | — |
| Yield of grain: Bushels per acre | | | | | | | | | |
| 1930 | Yield | 8.6 | 10.0 | 15.0 | 10.9 | 8.6 | 5.8 | 9.8 | 0.58 |
| | Per cent of Mean | 87.7 | 102.0 | 153.1 | 111.2 | 87.7 | 59.2 | 100.0 | 5.92 |
| 1931 | Yield | 18.1 | 15.1 | 17.1 | 16.9 | 14.9 | 9.6 | 15.3 | 1.17 |
| | Per cent of Mean | 118.3 | 98.7 | 111.8 | 110.5 | 97.4 | 62.7 | 100.0 | 7.65 |
| 1932 | Yield | 38.6 | 36.9 | 34.6 | 37.0 | 35.2 | 29.5 | 35.3 | 0.97 |
| | Per cent of Mean | 109.3 | 104.5 | 98.0 | 104.8 | 99.7 | 83.5 | 100.0 | 2.75 |

In Manitoba, where the dusting period is usually from four to five weeks, there is definite evidence to show that under ordinary field conditions relatively light sulphur dust applications (30 pounds per acre), at fairly close intervals (five days), will insure effective and economic control of stem rust of both wheat and oats, and reduce, by a very significant degree, the amount of leaf rust and crown rust. Apparently, frequency of application is a much more important factor in determining the effectiveness of sulphur dust treatments than is rate of sulphur application. The results have shown that early initial dust applications prevent the accumulation of viable inoculum on the plants and thus make the subsequent control of rust relatively easy.

It is difficult to formulate sulphur dusting schedules for rust control which would be applicable in all seasons and in all regions. To a very large extent the rate and frequency of dusting will have to be decided each year and as the season advances, according to the weather conditions, the progress of the rust, the condition of plant growth, and by the degree of control achieved by previous dust applications.

At present the sulphur dusting method is recommended for the use of experimentalists, seed growers, and grain exhibitors in the grain-growing regions of Canada. Whether or not dusting for the control of cereal rusts can be made a profitable agricultural practice will depend largely on such economic factors as, relative grain prices, cost of production, cost of dust fungicides and dusting equipment. The practical possibilities of dusting would be enhanced if more intensive cultural practices were employed. On the other hand, the general introduction of commercially desirable rust resistant varieties would remove the necessity of providing protection from cereal rusts.

## Summary

1. Field experiments to determine the most effective and practical method of dusting with sulphur for the control of leaf rusts and stem rusts of wheat and oats, were continued in 1930, 1931, and 1932, at Winnipeg, Manitoba.

2. Each year during the period of the experiments, relatively light applications of sulphur dust, well-timed and properly applied, almost completely controlled stem and leaf rusts of both wheat and oats. Furthermore, dusting prevented, to a marked degree, the development of some of the minor leaf and stem spotting diseases of these grain crops.

3. The effect of sulphur on the amount of rust infection, and on the consequent grain quality and yield, was least with light, infrequent dust applications, and greatest with heavy, frequent ones. In 1930, 1931, and 1932, during dusting periods of from four to five weeks, relatively light sulphur applications (30 pounds per acre), at close intervals (five days), gave very satisfactory results in preventing rusts and some of the minor diseases of both wheat and oats.

4. Yield and quality of the grain of both wheat and oats were significantly improved by dusting. In 1930, a severe rust year, the yield of Marquis wheat was increased 24.3 bushels per acre or approximately

400% by dusting, while eight 30-pound dustings improved the grain quality from "Feed" weighing 40 pounds per bushel to "1 Northern" weighing 60 pounds per bushel. By preventing rust in 1930, dusting increased the yield of Victory oats 45 bushels per acre or about 153%.

5. Of the dusts tested Kolodust, a finely-divided sulphur dust, gave the most effective rust control. The fungicidal value of sulphur increases in proportion to the fineness of the dust particles. Medium grades of sulphur dust gave very satisfactory results.

6. Sulphur dusting as a method of rust control is recommended for the use of experimentalists, seed growers, and grain exhibitors wherever destructive epidemics of cereal rusts occur.

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## RESUME

EXPÉRIENCES SUR LA FAÇON DE PRÉVENIR LES ROUILLES DES CÉRÉALES AU MOYEN D'UN SAUPOUDRAGE DE SOUFRE (1930-1932). F. J. Greaney, Laboratoire fédéral de recherches sur la rouille, Winnipeg, Man.

Les expériences qui avaient été entreprises à Winnipeg, Manitoba, pour connaître les moyens les plus efficaces et les plus pratiques de saupoudrer avec du soufre pour prévenir les rouilles des feuilles et les rouilles de la tige de l'avoine et du blé, ont été continuées en 1930, 1931 et 1932. Chaque année, pendant la période de ces expériences, des applications relativement faibles de poussière de soufre, appliquées au moment voulu et de la bonne façon, ont presque complètement maîtrisé la rouille de la tige et de la feuille du blé et de l'avoine. En outre, le saupoudrage a empêché à un degré remarquable le développement de quelques-unes des maladies secondaires

qui tachent les feuilles et les tiges de ces récoltes de grains. L'effet du soufre sur la quantité de rouille et sur la qualité et le rendement du grain des récoltes rouillées, était au minimum lorsque les applications de poussière étaient légères et peu fréquentes, et au maximum lorsqu'elles étaient fréquentes et abondantes. En 1930, 1931, et 1932, pendant des périodes de saupoudrage de quatre à cinq semaines, des applications relativement légères de soufre (30 livres par acre), à intervalles rapprochés (cinq jours), ont donné des résultats très satisfaisants en prévenant les rouilles et quelques-unes des maladies secondaires du blé et de l'avoine. Le rendement et la qualité du grain du blé et de l'avoine ont été beaucoup améliorés par le saupoudrage. En 1930, une année à rouille très grave, le saupoudrage a augmenté le rendement du blé Marquis de 24 3 boisseaux à l'acre, soit environ 400 pour cent, et huit saupoudrages de 30 livres chacun ont amélioré la qualité du grain depuis la catégorie à bétail, pesant 40 livres par boisseau, à la catégorie "du nord No. 1" pesant 60 livres par boisseau. En empêchant la rouille en 1930, le saupoudrage a augmenté le rendement de l'avoine Victoire de 45 boisseaux par acre, soit environ 153 pour cent. De toutes les poussières à l'essai, la Kolodust, une poussière de soufre finement divisée, est celle qui a donné le contrôle le plus efficace. La valeur fongicide du soufre augmente en proportion de la finesse des particules de poussière. Les catégories moyennes de poussière de soufre ont donné des résultats très satisfaisants. Le saupoudrage au soufre, pour prévenir la rouille, est recommandé aux expérimentateurs, aux producteurs de semence, et aux exposants de grains, partout où des épidémies destructives de rouille de céréales se produisent.

# LEAF AREA IN RELATION TO FRUIT SIZE AND TREE GROWTH[1]

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[Received for publication January 16, 1934]

## INTRODUCTION

Since fruit size is related directly to leaf area, as shown by Haller (*2*), Ellenwood (*1*), and Magness (*3*), it was felt that valuable information could be obtained by interpreting thinning distance in terms of leaf area per apple. Several investigators have demonstrated the relationship of leaf area to fruit size by means of ringed branches, and adjusted leaf areas, but little or no information is available concerning such a relationship under actual orchard conditions. The ringing of branches undoubtedly brings about in the limbs and their contributory root systems, abnormal physiological conditions which are bound to influence the data secured, and limit its degree of application. Accordingly, in the investigations described in this paper, the relation between leaf area and fruit development has been studied on trees growing naturally under normal orchard conditions.

## EXPERIMENTAL MATERIAL

The orchard of which the experimental trees form part, is situated on a flat bench gently sloping from west to east. The soil conditions are not of the best as the land is underlaid with gravel, which rises within two feet of the surface in some parts of the orchard. In an endeavour to compensate for the original handicap, special attention has been paid to building up the soil by means of leguminous cover crops. A determined effort has also been made to secure adequate and uniform distribution of irrigation water. This system of orchard management has resulted in healthy vigorous trees, which, for the most part, exceed average growth dimensions for their age.

The trees employed in this experiment are seventeen years old and for the past thirteen years have been used for a systematic test of various thinning practices. The orchard consists of two rows of trees of each of the four varieties, McIntosh, Delicious, Rome Beauty and Newtown. In each row there is a systematic distribution of heavily, medium, and lightly thinned trees. The systematic distribution of thinning treatments has been such as to overcome, as far as possible, any error due to soil differences. By "heavy" thinning is meant that the apples were spaced nine inches apart, by "medium" thinning, six inches apart, and by "light" thinning, three inches apart, provided there were sufficient fruiting spurs to permit of this spacing. In no case was more than one apple left to a spur. The thinning treatments have been applied annually to the same individual trees, so that it is now possible to study any cumulative effects that thirteen years of thinning may have produced.

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[1] This paper constitutes a report on one phase of a comprehensive apple thinning investigation in progress at the Dominion Experimental Station, Summerland.

[2] Student attached to the staff of the Dominion Experimental Station, Summerland.

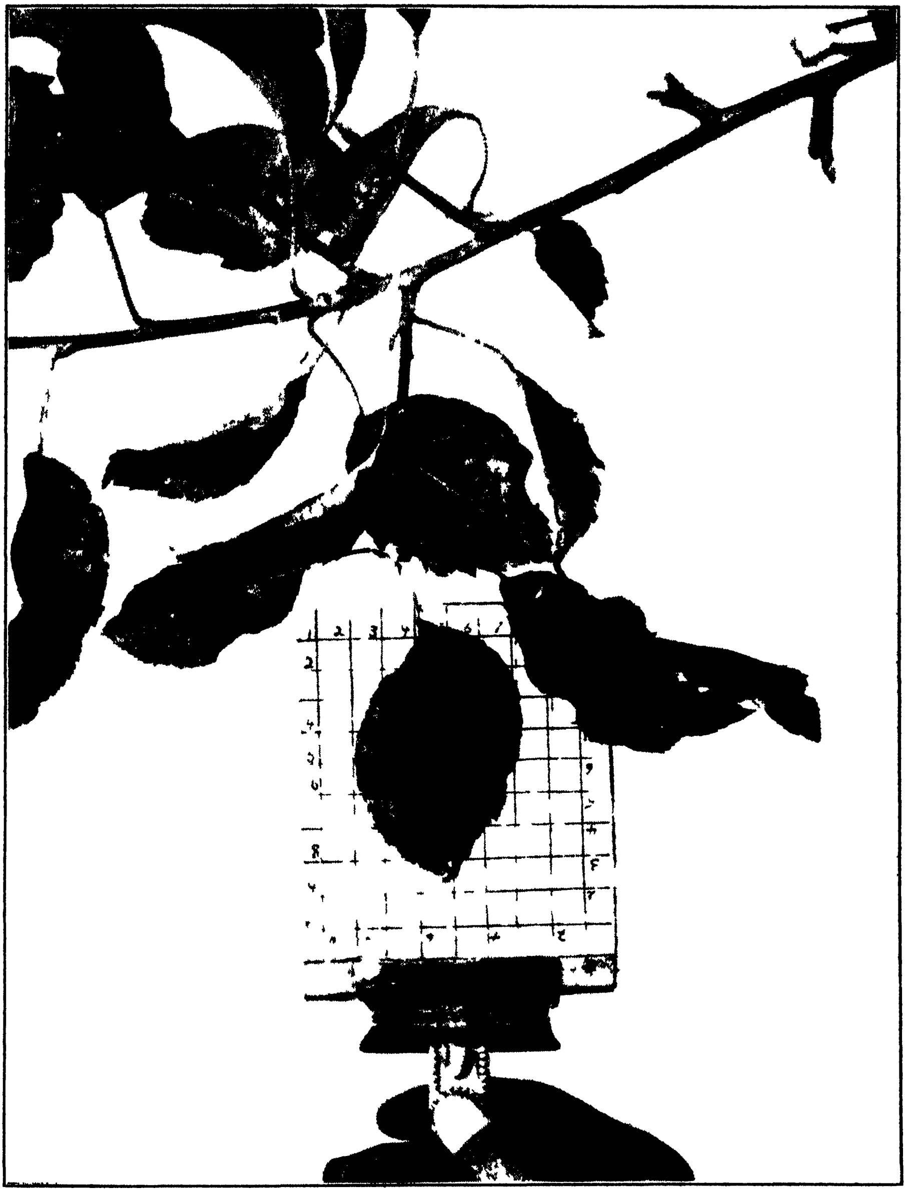

FIGURE 1. The "Integrator" in use.

## METHODS OF PROCEDURE

Large limbs have been selected for measurement of leaf areas per apple, so as to be able to depict, with as little error as possible, the actual relationships existing in the entire trees employed in this experiment. In each variety studied, three branches have been used, representative of the three thinning treatments applied. An attempt has been made to select on the experimental trees, branches carrying a maximum and uniformly distributed crop, according to the degree of thinning received, in order that results may be compared on an equitable basis.

The areas of the leaves have been measured on the branches by means of a small device known as an "integrator", which has been described by Vyvyan and Evans (*41*). This device consists of two plates, 10 cms. square, attached to the jaws of a strong paper clip. A slight pressure with the thumb and finger on the paper clip opens the jaws, permitting a leaf to be inserted between the plates. Releasing the pressure on the clip permits the jaws to close, flattening the leaf between the two plates. The upper plate is heavy glass, and is graduated in square centimeters, which facilitates rapid measurement of the leaf surface. A person experienced in the use of the integrator can measure, with an assistant to record the data, 400 to 500 leaves per hour. Figure 1 shows the integrator in use.

## PRESENTATION OF RESULTS

The areas of individual leaves were found to range between 1 and 76 square centimeters, while the averages ranged between 10 and 15 square centimeters. Table 1 shows the number of leaves, leaf size and leaf area per apple for four varieties of apples thinned to three different distances.

TABLE 1.—NUMBER OF LEAVES, LEAF SIZE, AND LEAF AREA PER APPLE

| Variety | Thinning distance, inches | No. of apples | No. of leaves | No. of leaves per apple | Leaf area per apple, sq. cm. | Average leaf size, sq. cm. |
|---|---|---|---|---|---|---|
| McIntosh | 9 | 58 | 3525 | 61.00 | 813.50 | 13.35 |
| | 6 | 45 | 1883 | 41.00 | 524.38 | 12.54 |
| | 3 | 112 | 2790 | 25.00 | 314.50 | 12.63 |
| | | | | | Average | 12.84 |
| Delicious | 9 | 90 | 4867 | 54.10 | 663.10 | 12.17 |
| | 6 | 122 | 3905 | 32.00 | 318.00 | 9.95 |
| | 3 | 76 | 1974 | 26.15 | 299.30 | 11.15 |
| | | | | | Average | 11.09 |
| Rome Beauty | 9 | 99 | 2847 | 27.89 | 380.50 | 13.21 |
| | 6 | 68 | 1599 | 23.50 | 260.00 | 11.06 |
| | 3 | 127 | 2526 | 19.90 | 241.90 | 12.15 |
| | | | | | Average | 12.14 |
| Newtown | 9 | 105 | 2281 | 21.75 | 285.60 | 13.13 |
| | 6 | 134 | 2184 | 16.28 | 235.00 | 14.41 |
| | 3 | 141 | 2154 | 15.27 | 220.60 | 14.46 |
| | | | | | Average | 14.00 |

With all four varieties it is evident that leaf area per apple increased as thinning severity increased. This result is to be expected since heavy thinning allows a greater number of leaves and a greater leaf surface per apple than does light thinning. However, it is interesting to note that difference in leaf area per apple between lightly and heavily thinned branches was influenced by variety. Thus, with McIntosh, the leaf area per apple was nearly three times greater on the heavily thinned than on the lightly thinned branch, while with Rome Beauty, the leaf area per apple was only one and one-half times greater in the case of the heavily thinned branch. Newtown showed a still smaller difference. It seems necessary to assume, therefore, that differences in leaf area per apple must be influenced by some factor or factors operating apart from the differences caused by the distance of thinning itself.

Density of the foliage carried by the tree is one important factor influencing leaf area per apple. This factor is an inherent characteristic fluctuating from variety to variety. Thus, it is a well known fact, fully substantiated by the data secured in this experiment, that Delicious has smaller leaves and fewer of them than does McIntosh. Another factor that influences leaf area per apple is the manner in which a variety sets its fruit. McIntosh and Newtown being subject to what is known as "biennial bearing" usually produce an extremely heavy crop one year and an extremely light one the next. This is in direct contrast with varieties like Rome Beauty and Delicious which tend to produce a medium crop, year in and year out. Thus, it is difficult to compare the leaf area per apple of McIntosh and Newtown with that of Rome Beauty and Delicious, because with the first two varieties, a maximum crop is borne in the bearing year, while with the other two a medium but unevenly distributed crop is carried by the tree every year. However, as previously stated, an attempt has been made to overcome this difficulty by selection of limbs carrying a full load.

The difference in leaf area per apple between 9- and 6-inch thinned branches was, in every case, greater than the corresponding difference between 6- and 3-inch thinned branches. This can be attributed at least in part to the fact that 3- and 6-inch thinning consisted mainly in thinning out similarly spaced clusters of fruit, while 9-inch thinning resulted in the removal of some of these clusters entirely. This was found to be especially true of the Rome Beauty variety.

The average size of the leaves in a given variety varied slightly with the thinning treatments applied, larger leaves tending to occur with heavier thinning. Newtown had the largest sized leaves of any variety studied, although the density of the foliage, when measured by the number of leaves per apple, was the least of any variety examined. McIntosh, on the other hand, while rating only second highest in size of leaf, by far exceeded any other variety, in both the number of leaves, and the average leaf surface per apple. This probably explains why McIntosh can mature to marketable size a far heavier crop of fruit than almost any other variety.

The relation of thinning distance, leaf area and fruit size is of especial interest in connection with Delicious, since it has been demonstrated at this station that heavy thinning of this variety has been profitable due to greater returns resulting from larger and better coloured fruit. The data presented in Table 1 suggest that this increase in size from heavy thinning is due to an increase in leaf area per fruit. It will be noted that by heavy thinning, leaf area was increased by 363 square centimeters per apple, or more than double that of light thinning. In the case of Rome Beauty, leaf surface per apple was surprisingly low in every instance. This was hardly to be expected, since this variety matures unusually large-sized fruits. The explanation may lie in greater photosynthetic efficiency of Rome Beauty leaves, and in the utilization of a greater proportion of the manufactured food for fruit production, as opposed to wood growth in this variety, than was the case with the other varieties studied. Additional data bearing on this point are presented in Table 2.

Since it was desired to discover whether there was any significant difference in the photosynthetic efficiency of the leaves of the different varieties, the weight as well as the number of apples harvested from each experimental limb was recorded at picking. The weight of the apples harvested was divided by the number of apples on each experimental limb, and hence the average weight per apple obtained. This was found to increase progressively as the severity of thinning increased. The varieties maturing the largest sized fruit were McIntosh and Rome Beauty.

TABLE 2.—WEIGHT PER APPLE AT HARVEST, AND WEIGHT OF FRUIT PRODUCED PER 100 SQUARE CENTIMETERS OF LEAF AREA

| Variety | Thinning distance, inches | Average weight per apple at harvest, lb. | Weight of fruit produced per 100 sq. cm. leaf area, lb. | Average, lb. |
|---|---|---|---|---|
| McIntosh | 9 | 0 433 | 0.0532 | |
| | 6 | 0 344 | 0.0657 | |
| | 3 | 0 336 | 0.1068 | |
| | | | ——— | 0 0752 |
| Delicious | 9 | 0.385 | 0.0582 | |
| | 6 | 0.291 | 0.0915 | |
| | 3 | 0.294 | 0.0983 | |
| | | | ——— | 0.0827 |
| Rome Beauty | 9 | 0 416 | 0 1095 | |
| | 6 | 0 303 | 0 1166 | |
| | 3 | 0.256 | 0.1050 | |
| | | | ——— | 0 1104 |
| Newtown | 9 | 0.247 | 0.0865 | |
| | 6 | 0.225 | 0 0958 | |
| | 3 | 0.172 | 0.0780 | |
| | | | ——— | 0.0868 |

From the data presented in Table 2, it is apparent that Rome Beauty produced by far the greatest weight of fruit per unit of leaf area. This suggests that the photosynthetic efficiency of Rome Beauty may be greater than that of other varieties. In fact, Rome Beauty, being an annual bearer, may possess still greater photosynthetic activity than the results would indicate, since this variety not only produces a large amount of fruit with a relatively small leaf area, but is able to synthesize sufficient surplus food to develop a new set of fruit buds for the following season.

It is interesting to note (Table 2, column 3) that the weight of fruit produced by 100 square centimeters leaf area was by no means constant, even within the varieties themselves. Thus, in McIntosh and Delicious, 100 square centimeters of leaf surface produced a much smaller weight of fruit on the heavily thinned than on the medium and lightly thinned branches. If we assume that the photosynthetic efficiency of the leaves in a given variety is a constant, we may postulate that in the case of the heavily thinned trees more food has been translocated back to feed the tree than in the case of the medium or lightly thinned trees, because in the latter instance the greater volume of fruit produced has demanded a relatively greater supply of food. Data supporting this assumption are presented in Table 3.

After twelve years of systematic thinning involving the same trees each year, heavily thinned trees have grown on the average, a significantly greater amount than lightly thinned trees. This is especially true of the varieties McIntosh and Delicious whose growth records are shown in Table 3.

TABLE 3.—TRUNK CROSS-SECTIONAL AREAS OF DIFFERENTLY THINNED TREES

| Variety | Area of trunk cross-section in square inches | | |
|---|---|---|---|
| | 9-inch thinning | 6-inch thinning | 3-inch thinning |
| Delicious | 124.1 | 104.6 | 99.9 |
| McIntosh | 156.2 | 124 7 | 122.6 |
| Rome Beauty | 96.0 | 93.4 | 81.0 |
| Newtown | 98 8 | 95.8 | 93.2 |

In the varieties Rome Beauty and Newtown there appeared to be relatively little differential effect in the amount of apple tissue produced by a given leaf area on the differently thinned branches. Similarly, in the trunk measurements just presented, it will be seen that the difference in tree growth between lightly and heavily thinned trees is not nearly so striking as in the case of McIntosh and Delicious.

The fact that, of the four varieties studied, Rome Beauty has produced the smallest trees, lends weight to the suggestion that in this variety a comparatively large percentage of the manufactured food is used in the production of fruit, leaving less to be translocated to other parts of the tree.

## SUMMARY

1. The leaf area per apple was determined on three differently thinned branches of each of the varieties McIntosh, Delicious, Rome Beauty and Newtown.

2. McIntosh and Delicious had the densest foliage, and Rome Beauty and Newtown the lightest.

3. Newtown had the largest leaves, followed by McIntosh, Rome Beauty and Delicious.

4. The size of fruit was positively correlated with leaf area per apple.

5. In each variety the weight of fruit produced per 100 square centimeters leaf area was determined. This was found to be least in the case of McIntosh and greatest in the case of Rome Beauty. It is suggested that these results may be due to differences in photosynthetic efficiency of the leaves.

6. Heavily thinned trees grew more than lightly thinned trees. It is suggested that in the former case more synthesized food materials were available to be translocated back into the tree.

## ACKNOWLEDGMENTS

The writer wishes to express his gratitude to Mr. R. C. Palmer, under whose direction this project was conducted, for helpful guidance during the progress of the work and preparation of the manuscript; to Messrs. F. N. Hewetson and H. Smith for assistance with the tedious operation of measuring the leaf areas; and to Mr. J. E. Britton for taking the photograph presented in Figure 1.

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## RESUME

RAPPORTS ENTRE LA SUPERFICIE DES FEUILLES, LA GROSSEUR DES FRUITS ET LA POUSSE DE L'ARBRE. D. V. Fisher, Station expérimentale fédérale, Summerland, C.-B.

L'étendue de feuilles par pomme a été déterminée sur trois branches éclaircies de façons différentes de chacune des variétes McIntosh, Délicieuse, Rome Beauty, et Newtown. Les McIntosh et Délicieuse avaient le feuillage le plus épais, et les Rome Beauty et Newton, le feuillage le plus clair. La grosseur des fruits était clairement reliée à l'étendue en feuilles par pomme. On a constaté que le poids des fruits produits par 100 cm. c. de l'étendue en feuilles était moindre pour la McIntosh et plus grand pour la Rome Beauty. Les résultats donnent à croire qu'il existe une différence dans l'efficacité photo-synthétique des feuilles de différentes variétés. Les arbres soumis à un fort éclaircissage se sont mieux développés que les arbres légèrement éclaircis, ce qui donne à croire qu'il existait, chez les premiers, plus de principes fertilisants synthétisés pour être retransportés dans l'arbre.

# THE ECONOMIC SITUATION

PREPARED IN THE AGRICULTURAL ECONOMICS BRANCH, DEPARTMENT OF AGRICULTURE, OTTAWA, FROM BASIC DATA COLLECTED BY THE DOMINION BUREAU OF STATISTICS

The index number of wholesale prices in Canada computed by the Dominion Bureau of Statistics was 72.0 in March as compared with 72.1 in February. Among the sub-indexes, those of vegetable products; fibres, textiles and textile products; wood, wood products and paper; iron and its products; non-metallic minerals and their products; and chemicals and their products advanced. Animals and their products, and non-ferrous metals and their products declined.

*Retail Prices.*—The total index of retail prices and costs of services advanced one point in March, the index of food prices rising from 69.4 to 72.9. There was a slight recession in the clothing index.

*Employment.*—The seasonally adjusted index of employment in Canada was 96.7 at the first of April as compared with 97.4 at the first of March. In manufacturing industries there was a distinct gain, but in the mining, construction, and maintenance groups there were declines.

*Physical Volume of Business.*—The physical volume of business showed a distinct gain in March, when the index rose to 93.1. Industrial production advanced from 84.0 in February to 92.0 in March. Among the sub-indexes mineral production rose sharply from 117.2 to 149 0. Nickel, zinc and gold reached new high points; in fact, only the production of silver was lower than in the preceding month. Manufacturing showed a substantial increase for which food stuffs, automobile production, imports of textiles and petroleum, and newsprint production were chiefly responsible. Output of newsprint reached the highest figure since October, 1930. Carloadings advanced and exports in general were considerably above those in the previous month.

*Agricultural Products.*—The index of wholesale prices of Canadian farm products receded to 56 5. The index of prices of grains rose fractionally to 49.5, largely because of somewhat higher values for wheat and hay. The index of animal products, however, fell from 72.5 to 68 3. This decline was primarily due to lower prices for hogs, calves, eggs, wool, hides, and skins. Agricultural marketings were, on the whole, lower in March than was the case in February; the index thus receded from 67.1 to 63 8. The index of grain marketings declined from 66.4 to 58.7. The movement of wheat was slightly above that for February, but shipments of oats, barley, flax, and rye were unusually low. Live stock marketings declined from 94.0 to 86.4. The index of cattle marketings receded from 88.4 to 86.4. Hog marketings stood at 81.2 as compared with 88 6 in February.

*Cold Storage Holdings.*—The index of cold storage holdings fell to 97.0 at March 1 and dropped to 84.2 at April 1, which indicates the continuance of a more rapid movement of goods into consumption.

*The Situation in General.*—During the first three months of 1934 the index of wholesale prices rose about 2 points. Prices of farm products advanced sharply in February but eased off again in March. The advance was largely due to a rise in prices of animal products because the index of prices of field products has shown only a moderate gain. Retail prices tended toward higher levels. The index numbers of prices in general are well above those of a year ago. The physical volume of business showed a substantial gain. Agricultural marketings have been relatively light, cold storage holdings declined during the first quarter of 1934 and were considerably lower than those in the first three months of 1933.

## ANNUAL AND MONTHLY INDEX NUMBERS OF PRICES AND PRODUCTION COMPUTED BY DOMINION BUREAU OF STATISTICS

| Year | Wholesale Prices 1926 = 100 | | | | Retail prices and cost of services (5) | Production (6) 1926 = 100 | | | |
|---|---|---|---|---|---|---|---|---|---|
| | All commodities (1) | Farm products (2) | Field products (3) | Animal products (4) | | Physical volume of business | Industrial production | Agricultural marketings | Cold Storage holdings |
| 1913 | 64.0 | 62.6 | 56.4 | 77.0 | 65.4 | | | | |
| 1914 | 65.5 | 69.2 | 64.9 | 79.0 | 66.0 | | | | |
| 1915 | 70.4 | 77.7 | 76.9 | 79.2 | 67 3 | | | | |
| 1916 | 84.3 | 89.7 | 88.4 | 92.3 | 72.5 | | | | |
| 1917 | 114.3 | 130.0 | 134.3 | 119.6 | 85.6 | | | | |
| 1918 | 127.4 | 132.9 | 132.0 | 134.7 | 97.4 | | | | |
| 1919 | 134.0 | 145.5 | 142.4 | 152.5 | 107.2 | 71.3 | 65 5 | 48.1 | 47.1 |
| 1920 | 155.9 | 161.6 | 166.5 | 149 9 | 124.2 | 75.0 | 69 9 | 52.6 | 94.2 |
| 1921 | 110.0 | 102.8 | 100 3 | 108 5 | 109 2 | 66.5 | 60 4 | 65.2 | 86.4 |
| 1922 | 97 3 | 86.7 | 81.3 | 99.1 | 100.0 | 79.1 | 76.9 | 82.6 | 82.8 |
| 1923 | 98.0 | 79.8 | 73.3 | 95.1 | 100.0 | 85.5 | 83.8 | 91.4 | 87.6 |
| 1924 | 99 4 | 87.0 | 82.6 | 97 2 | 98.0 | 84.6 | 82.4 | 102.5 | 114.9 |
| 1925 | 102.6 | 100.4 | 98.1 | 105.7 | 99.3 | 90 9 | 89.7 | 97.2 | 108.6 |
| 1926 | 100.0 | 100.0 | 100.0 | 100.0 | 100 0 | 100.0 | 100.0 | 100.9 | 100.0 |
| 1927 | 97.7 | 102.1 | 99.9 | 105.7 | 98 4 | 106.1 | 105.6 | 103.6 | 110.0 |
| 1928 | 96 4 | 100.7 | 92.6 | 114.3 | 98.9 | 117.3 | 117.8 | 146.7 | 112.8 |
| 1929 | 95.6 | 100 8 | 93.8 | 112.5 | 99 9 | 125.5 | 127.4 | 101.1 | 109.6 |
| 1930 | 86.6 | 82.3 | 70 0 | 102.9 | 99.2 | 109.5 | 108.0 | 103.0 | 128.4 |
| 1931 | 72.2 | 56.3 | 43.6 | 77 6 | 89.6 | 93.5 | 90.4 | 99.0 | 125.7 |
| 1932 | 66.7 | 48.4 | 41.1 | 60.7 | 81.4 | 78.7 | 74.0 | 114.3 | 120 1 |
| 1933 | | | | | | | | | |
| Jan. | 63.0 | 43.6 | 35.1 | 57.9 | 79 1 | 68 1 | 62 2 | 56.1 | 112.0 |
| Feb. | 63.6 | 43.0 | 36.0 | 54.7 | 78 4 | 67.0 | 60.0 | 76.5 | 127.6 |
| Mar | 64 4 | 44 7 | 38 0 | 56.0 | 77 8 | 68 4 | 62.5 | 129.0 | 135.8 |
| April | 65 4 | 46 8 | 41 1 | 56.4 | 78.1 | 69.8 | 65 1 | 104.1 | 112.7 |
| May | 66 9 | 51.2 | 46.9 | 58.4 | 77.0 | 76 4 | 72.7 | 95 4 | 110.4 |
| June | 67.6 | 52 6 | 49 4 | 57.9 | 77.0 | 82 2 | 79.8 | 221.9 | 119.9 |
| July | 70.5 | 60 1 | 60.8 | 59.0 | 77.2 | 84.1 | 82.6 | 221 9 | 119.9 |
| Aug. | 69.4 | 57.0 | 54 9 | 60.5 | 78.6 | 89 8 | 89.5 | 197.2 | 114.2 |
| Sept. | 68.9 | 54 7 | 49.5 | 63.4 | 78.8 | 90.8 | 90 2 | 101.1 | 115.7 |
| Oct. | 67.9 | 51.4 | 44 6 | 62.8 | 77.9 | 88 2 | 87.4 | 70.5 | 112.7 |
| Nov. | 68.7 | 53.8 | 46 7 | 65.8 | 78 1 | 85 5 | 83.9 | 41.8 | 111.1 |
| Dec. | 69.0 | 53.3 | 45.3 | 66.6 | 78.4 | 86.2 | 85 1 | 30.7 | 107.6 |
| 1934 | | | | | | | | | |
| Jan. | 70 6 | 55.3 | 47.9 | 67.8 | 78.7 | 86.8 | 84 5 | 48.2 | 108.1 |
| Feb. | 72.1 | 58 0 | 49.3 | 72.5 | 79.2 | 86.4 | 84.0 | 67.1 | 98 6 |
| Mar. | 72.0 | 56 5 | 49.5 | 68.3 | 80 2 | 93 1 | 92.0 | 63.8 | 97.0 |

1. See Prices and Price Indexes 1913-1928, pp. 19-21, 270-289 and 1913-1931, p. 15.
2. Wholesale prices of Canadian products of farm origin only. See Prices and Price Indexes 1913-1931, p. 33, and Monthly Mimeographs 1932 and 1933.
3. Wholesale prices of grains, fruits and vegetables.
4. Wholesale prices of Animals and Animal Products.
5. Including foods, rents, fuel, clothing and sundries, See Prices and Price Indexes 1913-1928, pp. 181-185, 290-293. 1926=100.
Prices and Price Indexes 1913-1931, p. 122, and Monthly Mimeographs 1932-1933.
6. Monthly Review of Business Statistics, p. 8, and Monthly Indexes of the Physical volume of business in Canada, supplement to the Monthly Review of Business Statistics, November, 1932.

*Imports and Exports.*—Imports into Canada in January, 1934, amounted to $32,391,000 as compared with $24,441,133 in January, 1933. In February, 1934, imports were valued at $33,592,000 as compared with $23,514,000 in the same month in 1933. In March of this year imports were valued at $47,497,000, while in March last year the figure was $32,963,000.

Comparing exports in the same period, those in January, 1934, amounted to $46,652,000 as compared with $31,562,000 in January, 1933. The figures for February were $37,842,000 and $26,397,000 respectively, while in March, 1934, exports were valued at $57,662,000 as against $36,579,000 in March, 1933.

From an agricultural point of view the wheat situation is probably most serious. Large crops in importing countries and low purchasing power have affected demand more than quotas established under the World Wheat Agreement. In this connection "The Monthly Review of the Wheat Situation", April 23, 1934, published by the Dominion Bureau of Statistics, states: "World trade in wheat continues on a small scale. From August 1, 1933, to April 16, 1934, world shipments of wheat and flour amounted to 378 million bushels as compared with shipments of 456 million bushels during the corresponding period in the previous cereal year. The London Wheat Conference estimated world import demand at 560 million bushels. On this basis a balance of 182 million bushels remains to be shipped during the remaining 15 weeks of the crop year. It would appear that a noticeable improvement in demand must take place if importing countries are to require 560 million bushels during 1933-34."

In the industrial situation one unfavourable factor may be noted, namely, that the construction index has risen but little in March. This affects the building trades and allied industries.

## LA SITUATION ECONOMIQUE

PREPARE PAR LA DIVISION DE L'ECONOMIE AGRICOLE DU MINISTERE DE L'AGRICULTURE, OTTAWA, ET BASE SUR LES DONNEES RECUEILLIES PAR LE BUREAU FEDERAL DE LA STATISTIQUE

Le chiffre indice des prix de gros au Canada, computé par le Bureau fédéral de la Statistique, était de 72.0 en mars contre 72 1 en février. Parmi les sous-indices, ceux des produits végétaux, des fibres, des textiles et des produits textiles, du bois, des produits du bois et du papier, du fer et ses produits, des minéraux non métalliques et leurs produits, et des ingrédients chimiques et leurs produits ont monté; ceux des animaux et leurs produits et des métaux non ferreux et leurs produits ont baissé.

*Prix de détail.*—L'indice total des prix de détail et des frais de services est monté d'un point en mars, l'indice des prix des aliments est passé de 69.4 à 72.9. Il y a eu une légère diminution dans l'indice des vêtements.

*Embauchage.*—L'indice de l'embauchage au Canada, ajusté pour la saison, était de 96.7 au 1er avril contre 97.4 au 1er mars. Il y a eu un gain considérable dans l'industrie manufacturière, mais des baisses dans les industries minières, de construction et d'entretien.

*Volume physique des affaires.*—Le volume physique des affaires a enregistré un gain net en mars, lorsque l'indice s'est élevé à 93 1. La production industrielle est passée de 84.0 en février à 92.0 en mars. Parmi les sous-indices, la production minérale s'est élevée brusquement de 117.2 à 149.0. Le nickel, le zinc et l'or ont atteint de nouveaux points élevés; en fait, seule la production de l'argent était plus faible que celle du mois précédent. L'industrie manufacturière a révélé une augmentation considérable, qui était due principalement aux denrées alimentaires, à la production des automobiles, aux importations de tissus et de pétrole, et à la production de papier à journaux. La production de ce papier a atteint le plus haut chiffre depuis le mois d'octobre 1930. Les chargements de wagons ont augmenté et les exportations en général étaient bien supérieures à celles du mois précédent.

*Produits agricoles.*—L'indice des prix de gros des produits de ferme canadiens est tombé à 56.5. L'indice des prix des grains s'est élevé d'une fraction à 49.5, surtout à cause d'une légère augmentation des prix du blé et du foin. Par contre, l'indice des produits animaux est tombé de 72.5 à 68.3, principalement à cause d'une diminution de prix sur les porcs, les veaux, les œufs, la laine, les cuirs et les peaux. Tout considéré, les ventes de produits agricoles en mars ont été inférieures à celles de février, et l'indice a diminué de 67.1 à 63.8. L'indice des ventes de grains a baissé de 66.4 à 58.7. Le mouvement du blé a été légèrement supérieur à celui de février, tandis que les expéditions d'avoine, d'orge, de lin et de seigle

étaient très basses. Les ventes de bestiaux ont baissé de 94.0 à 86.4. L'indice des ventes de bovins a baissé de 88 4 à 86 4. Les ventes de porcs étaient à 81.2 contre 88.6 en février.

*Produits conservés au froid.*—L'indice des produits frigorifiés, qui était à 97.0 au 1er mars est tombé à 84 2 au 1er avril, ce qui indique que les produits entrent plus rapidement en consommation.

*La situation en général.*—Pendant les trois premiers mois de 1934 l'indice des prix de gros s'est élevé de 2 points. Les prix des produits agricoles ont monté brusquement en février pour redescendre en mars. La hausse était due principalement à un gain dans les prix des produits animaux parce que l'indice des prix des produits des champs n'accusait qu'un gain modéré. Les prix de détail tendaient à monter à des niveaux plus élevés. Les indices des prix en général étaient bien supérieurs à ceux de l'année précédente. Le volume physique des affaires accusait un gain substantiel. Les ventes agricoles ont été relativement faibles, la quantité de produits frigorifiés a diminué pendant le premier trimestre de 1934 et elle était bien inférieure à celles des trois premiers de 1933.

*Importations et exportations.*—En janvier 1934, les importations au Canada se sont chiffrées par $32,391,000 contre $24,441,133 en janvier 1933. En février 1934, les importations étaient évaluées à $33,592,000 contre $23,514,000 pendant le même mois en 1933. En mars de cette année, les importations étaient évaluées à $47,497,000, tandis qu'en mars l'année dernière elles étaient à $32,963,000.

Si nous comparons les exportations pendant la même période, celles de janvier 1934 se sont montées à $46,652,000 contre $31,562,000 en janvier 1933. Les chiffres pour février étaient de $37,842,000 et $26,397,000 respectivement, tandis qu'en mars 1934, les exportations étaient évaluées à $57,662,000 contre $36,579,000 en mars 1933.

Au point de vue agricole la situation du blé est peut-être des plus sérieuses. Les grosses récoltes dans les pays importateurs et le faible pouvoir d'achat ont affecté la demande plus que les contingentements établis sous l'accord mondial du blé. Sous ce rapport, «La revue mensuelle de la situation du blé» (23 avril 1934), publiée par le Bureau fédéral de la Statistique, dit ce qui suit: «Le commerce mondial du blé continue sur une petite échelle. Entre le 1er août 1933 et le 16 avril 1934, les expéditions mondiales de blé et de farine se chiffraient par 378 millions de boisseaux, contre une quantité de 456 millions de boisseaux pendant la période correspondante de l'année précédente de céréales. La Conférence du blé de Londres estimait que les besoins d'importation pour le monde entier étaient de 560 millions de boisseaux. Sur cette base, il restait à expédier un reliquat de 182 millions de boisseaux pendant les quinze semaines restantes de l'année de récolte. Il semble qu'il faudra qu'une amélioration considérable se produise pour que les pays importateurs puissent prendre 560 millions de boisseaux en 1934-33.»

En ce qui concerne la situation industrielle, un facteur défavorable est à noter, c'est l'indice de la construction qui n'a fait que peu de progrès en mars. Ceci affecte les industries du bâtiment et les industries qui s'y rattachent.

## ANNUAL CONVENTION DATES

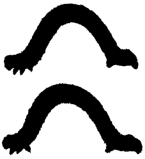
The annual convention of the Canadian Society of Technical Agriculturists is being held at Macdonald College and at the Oka Agricultural Institute at La Trappe, P.Q., from Monday, June 25 to Thursday, June 28. The annual convention of the Canadian Seed Growers' Association will be held at the same institutions and on the same dates.

During Monday, Tuesday and Wednesday mornings at Macdonald College the various groups and societies affiliated and co-operating with the C.S.T.A. will hold their business and technical sessions. These include the Canadian Phytopathological Society, the Canadian Society of Agricultural Economics, the Canadian Society of Animal Production (Eastern Section), the Horticultural Group, the Soils Group, and the Agricultural Engineering Group of the C.S.T.A.

# The Hemlock Looper

Eggs on the twigs

Pupa (natural size)



Caterpillars (nat. size)

Moth (nat. size)

Infested twig, early feeding

A looper outbreak balsam forest

Infested twig, end of feeding

SCIENTIFIC AGRICULTURE

Vol. XIV JUNE, 1934 No. 10

# AN ACCOUNT OF THE EASTERN HEMLOCK LOOPER, *ELLOPIA FISCELLARIA* GN., ON HEMLOCK, WITH NOTES ON ALLIED SPECIES

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[Received for publication, February 15, 1934]

## INTRODUCTION

During the summers of 1928 and 1929 the authors had the opportunity of studying an outbreak of *Ellopia fiscellaria* Gn. in the region of the Muskoka Lakes in the province of Ontario. The results of this study are admittedly fragmentary, but in view of the fact that comparatively little is known concerning this important insect, they are presented here in the hope that the information gained may be of use to other investigators who may wish to go more thoroughly into the study of the insect, as well as to property holders whose interests are menaced by this destructive pest. Whilst *E. fiscellaria* constitutes the principal subject of the present discussion, it was thought advisable to include some notes on such allied economic species or varieties as *E. somniaria* Hulst. and *E. athasaria* Wlkr., not only because these species are often confused in reports on infestations, but also because the many obvious points of similarity both in structure and in habits existing between them suggest, at least, the possibility of certain, less apparent, biological relations.

The junior author was entrusted with the field work in Muskoka during the greater part of the summer of 1928. Most of the findings on the bionomics of *E. fiscellaria* embodied in this paper should be credited to him.

## RECORDS OF INFESTATIONS BY *E. Fiscellaria* AND ALLIED SPECIES

We have endeavoured to bring together all the available records of extensive infestations by different species of *Ellopia*. These have been taken from the published literature and from the files of the Dominion Entomological Branch, Ottawa.

The infestations are listed below in the order of their occurrence. Usually we have adhered to the text and the nomenclature used in the original reports.

1882. J. J. WALKER, Ent. Month. Mag. 1888.

> "At Esquimalt, Vancouver Island, in the summer of 1882, all the oaks were stripped by the larvae of *Therina fervidaria* Hbn. and their trunks and branches were paved with the handsome geometrid moths in September."

1887. REV. G. W. TAYLOR, quoted in Report of the Entomologist and Botanist (Canada) 1890, p. 175.

> "This year has been pre-eminently a caterpillar year, and *Ellopia somniaria* stripped the oaks. These last were very numerous, and were most disagreeable

pests, dropping from their food plant and hanging by threads, so that even in walking through the trees it was almost impossible to keep them out of one's eyes and mouth. The threads and larvae were so numerous that it was most unpleasant to walk through the oak groves, and the sound of the falling excrement was suggestive of gentle rain."

1890. JAS. J. FLETCHER—Report of the Entomologist and Botanist (Canada) 1890. p. 175–177.

"Every three or four years the oaks in some districts in the vicinity of Victoria, Vancouver Island, are seriously disfigured by being defoliated by the caterpillars of a geometrid moth."

The report contains a good general account by W. H. Danby of the life-history and habits of the insect, and some remarks on the morphology, identity and control of the species by Dr. James Fletcher. Two parasites are mentioned, *Ichneumon cestus* and a *Pimpla* sp. The latter was described by Harrington as *Pimpla ellopiae*, Can. Ent. XXIV, p. 99.

1902–1903. In 1902 and 1903 several islands in the Muskoka Lakes district were severely infested by the Hemlock Looper, many trees were killed and had to be cut. The stumps of such trees could still be found in 1928. This infestation was reported orally by one of the old residents of the district.

1904–1905. Report of the Entomologist and Botanist (Canada) 1904, pp. 244–245.

"Mr. J. R. ANDERSON writes: 'The oak looper (*Ellopia somniaria*) appeared in vast numbers in some places on Vancouver Island this year. Strange to say, in certain localities they were entirely absent, but in others they were so numerous that they consumed every particle of their natural food, and they would then attack other trees, eating away a layer of the skin and large holes into the interior near the stem. They were also denuding the apple trees of their leaves. There were hundreds on one tree which stood beneath an oak. The larvae had defoliated the oak tree, then let themselves down in the usual manner, and were on the apple tree in hundreds eating the foliage and fruit. Other trees, as cherry, elm, etc., farther away were also attacked but not so much as those near the oaks.' *Ichneumon cestus* and *Pimpla ontario* Cress. are mentioned as parasites found in the material sent in by Mr. Anderson.

"Mr. A. W. HANHAM writes: 'Victoria, B.C., October 25.—The moths of the oak looper (*E. somniaria*) have this autumn been a sight to see. Out the Cadboro Bay road large oak trees were covered with the moths a couple of weeks ago, particularly on the underside of the branches and close to the trunks. There were numbers of reddish brown ichneumons, all of one species, which were flying about the trunk of the trees.' (*Ichneumon cestus* Cr.)

Report of the Entomologist and Botanist (Canada) 1905, p. 189.

"In Vancouver Island, the oak looper *Therina somniaria* Hlst., which was complained of as being abundant last year, during 1905 swarmed in countless numbers over the oak trees in the vicinity of Victoria, B.C., and stripped them of their leaves.—*Ibid.* pp. 193–194:

"The beautiful oak trees which form such an attractive feature of Victoria, Vancouver Island, have again this year suffered severely from the attacks of the caterpillars of this Geometrid moth. It was hoped from the large number of parasites which were reared from the pupae last autumn, that the injury during 1905 would have been less than in the preceding season. These hopes, however, were doomed to disappointment, for the caterpillars occurred last spring in countless myriads and stripped every vestige of foliage from most of the oaks around the city and for several miles out into the country." A discussion of the systematic status of the species follows and *Pimpla scriptifrons* Cresson is mentioned as a parasite.

1906. S. J. Houser *Ellopia athasaria* Wlkr. Journ. Ec. Ent. XX, 2, 1927.

This author mentions the report by an eyewitness of an infestation by *E. athasaria* (?) on hemlocks in the neighbourhood of Wheeling, West Virginia.

1911–1913. R. N. Chrystal, Agric. Gaz. Canada 1916. Forest Insect Investigations in Stanley Park, Vancouver.

"The damage effected by *Therina* caterpillars to hemlock, in 1911 to 1913 was very great, whole tracts of large trees being killed and a great number of others in various parts of the park being seriously if not irreparably damaged. Observations in 1914 showed a great diminution in the number of the caterpillars, the improvement in condition being particularly marked in the case of the younger trees along the driveways, which, completely defoliated in 1913, retained their foliage in 1914, those worst affected showing signs of a return to their normal condition again. This improvement in condition consequent on the control of the caterpillars was directly due to natural causes, chiefly insect parasitism which was very noticeable in 1914, the parasite being a tachinid fly. During 1915, hardly any signs of the caterpillars were seen in Stanley Park and the present summer (1916) shows a like condition."

1912–1915. C. G. Hewitt, Dom. Ent. Report 1912.

"An unusual outbreak of a geometrid, the caterpillar of which defoliated many thousands of acres of balsam in Newfoundland was reported to us by the Deputy Minister of Agriculture and Mines for that Colony, and on investigation it was found that the insect was *Therina fiscellaria*."

J. M. Swaine—unpublished report on the Newfoundland infestation in 1925.

"We know of four areas on the Port au Port peninsula, where, during 1912 and 1915, outbreaks similar to that now in progress on Nagle's hill (*Ellopia* sp.) destroyed nearly all the fir over many square miles of country."

1919–1920. Julius V. Hoffman, U.S.D.A.B. 1200–1924. Natural regeneration of Douglas fir in the Pacific N.W.

"In 1919 and 1920, the western hemlock looper (*Therina* (*Ellopia*) *somniaria* Hulst.) killed at least 400,000,000 board feet of high quality Douglas fir and Western hemlock in Tillamook county, Oreg. The dead trees scattered through this damaged area are now a serious fire risk, and if they should burn they would not only kill much of the timber that was left unscathed by the defoliators, but would also destroy the young growth which follows in such insect-killed areas."

1920–1925. J. M. Swaine, Unpublished Report (1925) *Ellopia* sp. in Newfoundland.

"When they occur in great numbers, the caterpillars defoliate the trees over wide areas. Trees which are completely defoliated in one season die rapidly and those which are partly defoliated are weakened in proportion to the amount of foliage that has been destroyed. An outbreak of this species (*Ellopia* sp.) has been in progress in the wood adjoining the city of St. John's for at least five years, and this summer the caterpillars were exceedingly abundant throughout the area between the Golf Course and Mt. Pearl Station. A large part of the fir, and spruce mixed with the fir, has already been killed on the hill sides opposite the city. The large brownish areas are covered with dead trees. The yellowish areas indicate severe defoliation this season and include a great number of weakened trees that will unquestionably die within the next few years.

"Local outbreaks by this insect are in progress in other parts of the Avalon Peninsula . . . . It is well demonstrated, through the outbreak now in progress on Nagle's Hill and the older injuries (1912–13) that occurred in the middle and west of the Island, that we have here a very destructive and dangerous pest, capable of causing very serious injuries where the most favourable conditions for its development obtain."

1924. R. H. Pettit, Rept. Mich. St. Ent. 1926.

"During the summer of 1924, northern Michigan was the scene of a slight attack of a measuring worm, the larva of a geometrid moth. This was followed during 1925 by a far more serious attack in the course of which a very considerable number of evergreen trees in the resort district of the North were partially or wholly defoliated, resulting too often in the death of the trees. The attack seemed at that time to have centered in Leelanan County and on July 4, 1925, was well under way, the most advanced of the larvae being almost fullgrown. . . . . Five areas of severe infestation were located. In all of these the death of many trees resulted. (Leelanan Co., Grand Transverse Co., Autrim Co. (2 areas), Emmet Co.). In addition to these five severely infested areas the pests were found in Benzie, Manistee, Charlevoix, Cheboygan and Otsego Counties. The greatest injury was done wherever hemlocks abounded." *See also:* Dibble, C. B., Mich. Quart. Bull. 8, 1926.

1924–1929. Muskoka Lakes region—Discussed in present paper.

1925. S. B. Fracker and A. A. Granowsky, Journ. Ec. Ent. 1927.

"In July, 1925, the superintendent of Peninsula State Park, Door County, Wisconsin, noticed that a fine stand of hemlocks was turning brown. Upon closer observation he discovered that they were being defoliated by measuring worms occurring in great numbers. The writers investigated the conditions on July 17 and found that the measuring worms were occurring in all the hemlock stands in the park as well as in other parts of the country . . . . Judging from the effects of these larvae, hemlock trees when completely defoliated, die without being able to put out a new set of leaves.

"The state forester estimates the loss in 1925 at 6,000,000 board feet. At one point practically no hemlocks of any age are living on an area of over ten acres while a large proportion of those over about thirty acres additional have been killed." *See also* S. B. Fracker, Am. Journ. of Forestry, 1927.

L. J. Houser, Journ. Ec. Ent. XX, 2, 1927. *Ellopia athasaria* Walker. Resumé:

"This Geometrid looper appeared in 1925 attacking hemlock in eastern Ohio. A few other forest trees were injured. Defoliation killed hundreds of hemlocks—some large enough for sawlogs. Scourge disappeared in 1926 probably as a result of the fungus *Sporotrichum globuliferum* attacking the *overwintering pupae.*"

1926. J. J. de Gryse, Unpublished Report, 1928. *Ellopia fiscellaria*

"Over an area about 15 miles in length, situated S.E. of Brockville on the Canadian shore of the St. Lawrence, all the hemlocks have been killed wherever they constitute a high percentage of the stands. Similar ravages are apparent on the opposite shore in the State of New York. This outbreak has been in progress since 1926."

1927. H. W. Crosbie. In correspondence, Tweed, Ont. (*Ellopia fiscellaria*).

"The area infested with these moths is situated in Clarendon Township, Frontenac County, on the north-west corner of an island in Gull Lake. The infested area is from ten to twelve acres in extent and does not appear to have increased in size since this time last year. It was first noticed by us in August, 1926, appearing from a distance to have been burned over by fire. On examination the trees were found to be defoliated and the ground covered with small hemlock needles. The moths were then present in swarms and when not flying were found on the tree trunks in bark cavities. In September of last year another visit was made to this area and although a thorough search was made no grubs or eggs could be located. This year in September the moths did not appear to be quite as numerous. Some of the trees were dead and some had started a new foliage, the needles being about half the ordinary length. This is the only area infested that I am aware of in this district and it is at least ninety miles from Brockville."

In the United States extensive infestations occurred in Jefferson County, N.Y. (U.S. Bur. Ent. Insect Pest Survey Bull., VII, pp. 341–342) and in some parts of Maine (Ibid. p. 300).

1928–1929. E. B. WATSON—Unpublished report of the North Shore outbreak.

"The hemlock looper occurs in outbreak form on the North Shore of the St. Lawrence in a number of places and from sources which are considered reliable, there is every reason to believe that the insect is widely distributed and that pure stands of balsam situated between the Pentecote and Manicouagan rivers, if not already infested, are threatened with attack from the looper at some future date."

This outbreak is fully discussed by E. B. Watson in the second paper of the present series.

W. G. MATHERS—Unpublished Report.

"An outbreak of *Ellopia somniaria* was found in progress at the head of the North arm of Burrard Inlet in British Columbia."

A new outbreak of hemlock looper in the balsam stands of Newfoundland was reported in 1928 by some of the limit-holders. The available details concerning this outbreak are meagre.

1929–1930. In the United States a severe outbreak of *E. fiscellaria* was reported from Pentwater, Mich. (U.S. Bur. Ent. Insect Pest Survey Bull., IX, p. 342), and an outbreak of *E. somniaria* was in progress in Willamette Valley, Ore. (Ibid. p. 346), in Amity, Ore. (Ibid. X, p. 429) and in Yamhill and Polk counties, Ore. (Ibid. X, p. 389). The principal food plant in Oregon was oak.

Several local outbreaks of *E. somniaria* were found in different parts of British Columbia. The principal host tree in all cases was hemlock. A detailed account of the outbreaks in British Columbia will be found in the paper on the Western hemlock looper by George Hopping.

## SYSTEMATIC POSITION AND PRINCIPAL CHARACTERISTICS OF THE SPECIES

The identity of the species of the genus *Ellopia*, with which this paper is concerned, has always been a moot question. In designating the species occurring in outbreak form the names *fervidaria*, *somniaria*, *fiscellaria* and *athasaria* have been employed rather indiscriminately. In the present paper we have adopted the name *E. fiscellaria* Guen. for the species occurring on hemlock and balsam fir in Eastern Canada. The species occurring on oak in Vancouver Island must probably be regarded as *E. somniaria* Hulst. The identity of the species feeding on Douglas fir and western hemlock in British Columbia is somewhat difficult to establish but, probably, it is a true *somniaria*. Hulst separated *somniaria* from *fervidaria* Hbn. mainly on colour and on the width of the transverse bands and the orange borders of the latter in the wings. The name *E. fervidaria* Hbn. cannot be applied to any of either the eastern or western forms discussed here. The forewings of the latter have distinctly angulate outer margins, whilst *fervidaria*, as figured by Hübner, has a smooth outer margin, besides possessing other characteristics such as the absence of the orange border of the transverse stripes in the wings and the smooth curve of these same stripes, which distinguish it from the typical *fiscellaria* or *somniaria*. *Ellopia athasaria* Wlkr. seems to be closer to *fervidaria* both in the shape of the wings and in the curve of the transverse stripes. Plate I, Figure 3 a–e, shows the various forms mentioned above. It would appear from Dyar's *(1)* and Houser's *(2)* statements that *Ellopia athasaria* differs in its life history as well. *E. fiscellaria* and *somniaria* overwinter in the egg stage, whilst *athasaria* hibernates as a pupa. It is not unlikely that as a result of careful breeding experiments further light may be thrown on the systematic position of the species or forms in question.

Only three larvae of *Ellopia somniaria* from Vancouver Island and five or six larvae of the British Columbia form were available for study. The Vancouver specimens were, moreover, in very poor condition. Practically no difference could be found between these and the Eastern specimens collected in the Muskoka region. The specimens from Vancouver Island appeared to be a little larger but this may be due to artificial distention resulting from treatment in caustic potash to which they had to be subjected before they could be used for examination. The body markings visible in the specimens from Vancouver correspond in every way to those of the eastern specimens. The setal arrangement of the head, thorax, and abdomen seems also to be similar. On the other hand, all the western specimens both from Vancouver Island and from British Columbia showed a noticeable reduction in the teeth of the mandibles as compared to those of the eastern larvae. In the latter the teeth are invariably sharp and clear cut whilst in the western species the teeth are blunt and sometimes almost completely obliterated. The scarcity of available western material leaves this point more or less open to doubt, but here we have at least some indication of a possible criterion for distinction between the Eastern and Western species or forms.

## Bionomics

### GEOLOGICAL AND TOPOGRAPHICAL NOTES

The whole region of the Muskoka Lakes is precambrian and is underlain principally by granite. The fertile soil is shallow and outcrops of bare rock are to be found everywhere. The humus is very shallow in general but increases in depth in low situations and in hardwood stands. The scarcity of fertile soil is probably due to burns which occurred some years ago, humus and mineral soil being washed away by rain in subsequent years. Parts of the country recently burned over show the effect of fire and rains very plainly.

Topographically the region is fairly uniform. The country is of a rolling character resulting in a very irregular shore line and numerous islands of varied sizes. The relative elevations above the level of the lake do not exceed 150 to 200 feet.

### FOREST TYPES

One may distinguish three main types of forest in the Muskoka Lakes region.

1. Old stands of hemlock, *Tsuga canadensis* (L) Carr. either pure or mixed to a small extent with white pine, *Pinus strobus* L. and different hardwoods, such as *Acer saccharum* Marsh., *Acer saccharinum* L., *Ulmus americana* L. and a few others. This type of forest is mostly over 80 years old and has not been touched by fire.

Areas covered with these stands are generally the north and northeast slopes of the low hills or parts of the mainland shore or islands where the soil moisture is comparatively high. The undergrowth in such stands is composed of ground hemlock, *Taxus canadensis*, and blueberries. In very dense stands the soil is covered with needle debris only. Natural reproduction of hemlock occurs in places where windfalls have brought in sufficient light. Good examples of this type are found on Loon, Cameron, Bell, Governors, Elsinore Island, etc. This forest type was most exposed to the recent hemlock looper attack.

2. Old stands of white pine which cover mostly the south and southwest sides of the hills and the drier situations represent the second type. These white pine stands are also mature and suffered apparently only little from fires. A pure stand is found on Cliff Island. More frequently white pine stands are mixed with hardwoods, such as *Quercus alba* Linn., *Quercus rubra* Linn., *Populus grandidentata* Michx., *Betula lutea* Michx., *Betula alba* L. var. *papyrifera* Spach., etc.

Hemlock occurs here scatteringly only and was not attacked by the looper. In light stands the undergrowth consists mostly of blueberries whilst in dense parts the soil is covered with needle litter.

3. The third type covers land recently burned over. It consists of hardwoods with scattered hemlock and white pine. It seems to be the preparatory stage for either the first or second type. Very few old hardwood stands can be found. The type changes its composition with its age. Birches and poplars begin the process of reforestation on the bare land on account of their light seed and their ability to grow in poor soils. Maples come next in succession. Some oaks occur here and there. In moist situations these young stands are mostly so dense that no other flora is able to exist beneath them. On south slopes and in dry places this process of natural reforestation meets many obstacles. The soil is mostly covered by blueberries and weeds which are strong competitors with forest reproduction. Silver Birches Island is an excellent example of this third type of forest.

*Pinus resinosa* Aiton is apparently introduced in this part of the country. There is a plantation on the west shore of Cameron Island.

## INTENSITY AND EXTENT OF THE INFESTATION IN THE MUSKOKA REGION IN 1928

According to information received from residents of the districts the infestation started on Morrison Island in 1925. In 1926 and 1927 Chief Island was heavily infested. There is little or no evidence for the belief that the infestation was spread by wind to other islands; it seems more reasonable to suppose that the infestation was autochtonous over the entire area and in all its parts.

In July, 1928, the percentage of killed hemlock over 3 inches DBH. ran from 10% to 100% in different localities.

In determining the grade of an infestation at the end of the season, counts of pupae found on the forest floor should furnish valuable information which might serve as the basis for a fairly exact prognostication of conditions for the coming year, with regard to both the looper population and the probable parasitism.

As no such counts had been made in 1927, twig samples were used in our study to obtain an idea of the degree of infestation. These samples consisted of 2 foot twigs which were cut off at a height within easy reach. All the larvae present on these were counted. The data shown in Table 1 were obtained from twig samples.

Since all the samples were not taken on one and the same day, there may be great differences from sample to sample in the population on the lower limbs of the trees owing to variations in weather conditions. After heavy winds and storms the number of larvae per twig would be higher than after a series of calm days.

TABLE 1.—DEGREE OF INFESTATION AS DETERMINED FROM TWIG SAMPLES

| Place | Date | No. of samples | Average No. of larvae per twig | Remarks |
|---|---|---|---|---|
| Cameron Island | July 4 | 13 | 35.0 | |
| Cameron Island | July 5 | 22 | 36.0 | |
| Cameron Island | July 10 | 58 | 26.9 | |
| Eagle Island | July 7 | 20 | 5.4 | |
| Chief Island | July 7 | 7 | 35.7 | Southwest corner |
| Loon Island | July 7 | 8 | 9.0 | |
| Loon Island | July 19 | 34 | 20.0 | |
| Badgerow Island | July 10 | 10 | 8.7 | |
| Badgerow Island | July 24 | 15 | 2.8 | |
| Morris Island | July 13 | 25 | 12.6 | |
| Mainland (East) | July 13 | 10 | 5.0 | |
| Mainland (East) | July 23 | 13 | 6.1 | |
| Rose Island | July 16 | 4 | 28.3 | |
| Black Forest Island | July 16 | 3 | 11.0 | |
| Bell Island | July 17 | 20 | 21.7 | |
| Bell Island | July 17 | 31 | 14.45 | Banded trees |
| Mainland (West) | July 17 | 27 | 4.3 | |
| Elsinore Island | July 18 | 25 | 12.68 | |
| Governor Island | July 18 | 25 | 26.3 | |
| Laurie Island | July 19 | 35 | 7.1 | |
| Caniff Island | July 17 | 10 | 4 2 | |
| Mainland (West) | July 13 | 13 | 18.9 | |

## LIFE HISTORY AND HABITS

*The Eggs.*—The newly laid eggs are light grass-green in colour. They measure from 0.71 to 0.96 mm. in width. They are broadly oval in shape and have a flattened area at one pole. To the naked eye the shell appears smooth, but shows fine reticulations under the microscope. After about two weeks the eggs change to a copper brown and become opalescent. Before hatching the colour becomes darker and the head capsule can be seen through the shell.

The eggs are laid either singly or in small groups of two or three on the twigs, on the needles or in the crevices of the bark of living trees. Eggs were also found on buildings, in the small cracks of shingles, on stumps and on fallen trees. Considerable difficulty was always experienced in finding eggs in nature. The insect overwinters in the egg stage.

*The Larva* (Plate I, Figure 1).—There are apparently five larval stages. The approximate width limits of the head capsules for each stage are given below:—

1st stage, 0.30–0.35 mm.
2nd stage, 0.44–0.72 mm.
3rd stage, 0.75–0.98 mm.
4th stage, 1.05–1.60 mm.
5th stage, 1.68–2.30 mm.

The following are the principal characters by which the stages may be distinguished.

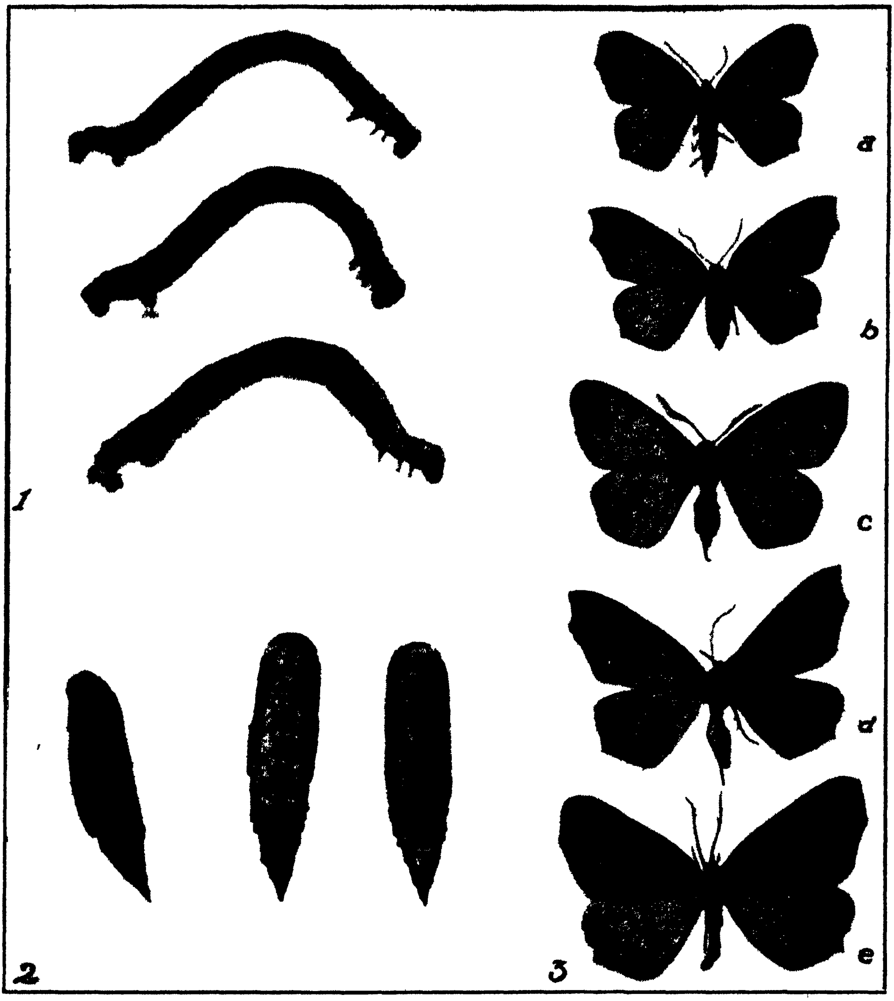

PLATE I

1. *Ellopia fiscellaria* Gn. — Different types of larvae. 2. *Ellopia fiscellaria* Gn. — Pupa. Lateral, dorsal and ventral views. 3. *Ellopia* spp. — *a* – *E. fiscellaria* Gn., male; *b* – *E. fiscellaria* Gn., female; *c* – *E. athasaria* Wlkr., male; *d* – *E. somniaria* Hlst., female; *e* – *E. somniaria* Hlst., male.

First stage larva.—The freshly emerged larva is dull white in colour with the head capsule dark brown. Two narrow dark longitudinal stripes run on each side of the body, the one is subdorsal, the other sublateral. Each thoracic segment bears a broad, dark brown, transverse band on the dorsum. On the abdominal segments similar bands encircling the entire segment occur.

Second stage larva.—The head capsule is dark brown, with light spots especially around the dark setae. The body is more greenish than in the first stage, and the markings are faint, irregular, interrupted and often confused.

Third, fourth and fifth stage larvae.—In the third, fourth and fifth stages the head capsules are of the same colour as the body. Many variations of the body colour from very pale green to dark brown were observed. The markings become more irregular and comparatively less distinct in the later stages. On the head capsule there occur brownish markings forming irregular spots around the setae. Irregular markings of a pale yellowish brown are found between the setae. The base of the body setae is usually surrounded by dark brown spots or tubercles.

Some general observations on the duration of larval stages were made both in 1928 and 1929. The observations made in 1929 relate to the early stages. Those made in 1928 relate to the 4th and 5th stages. In 1929 the larvae hatched from the eggs probably about June 10th. Up to June 17 they were practically all in the first instar. On this date the first 2nd stage larva was found. Second stage larvae began to appear in numbers about June 20. The first 3rd stage larvae were found on June 27. One 4th stage larva was found on July 2. After July 10 (1928) the number of 4th stage larvae increased gradually, reaching its peak about July 25. The last specimens of this stage were taken on August 1. There is considerable overlapping of all the stages; third stage larvae, for instance, could be found as late as the beginning of September.

The fifth and last stage is apparently the longest. The first 5th stage larvae were collected on July 19; they increased rapidly in numbers, and on August 6 more than 85% of the caterpillars were in the last stage. The length of this stage varied considerably in different individuals.

The larvae spin actively during their entire life. Threads were found all over the infested areas. After heavy winds there was a maze of threads strung between the crowns of adjoining trees. When larvae are blown off the trees they often remain suspended on their threads. A larva hanging by its spinneret is not able to grasp its thread with the prolegs. In such cases the process of reascending the thread is accomplished by means of the thoracic legs only. The thread is caught by the first pair of legs, the body is turned and twisted around to enable the meso and metathoracic legs to grasp the strand after which the thorax is stretched and the prothoracic legs again grasp the thread. The head describes a movement somewhat similar to the figure 8. The thread is rolled into a skein between the thoracic legs as the larva pulls itself up. This procedure is quite a slow one. Whenever a larva is able to reach a thread by means of its prolegs, as when crossing another thread, it begins to measure along its own thread as if walking on a plane surface. In the later stages, the larvae have a tendency to hang motionless from their threads for longer periods than in the early stages.

In the region of Lake Joseph the preferred food plant is the eastern hemlock, *Tsuga canadensis* L. The larvae destroy a considerable amount of foliage by cutting the needles near the base or by feeding on them from one side only. Needles partly destroyed in this way eventually dry up and fall to the ground. Other plants were attacked only when associated with hemlock. Larvae were found feeding on practically all trees and shrubs and many of the lower plants except ground hemlock, *Taxus canadensis* Marshall.

Rearing experiments started with third and fourth stage larvae showed that the looper larva is probably able to complete its development on a great number of food plants. All observations in the Muskoka Lakes region lead to the belief that the early stages only, namely the first and second, are restricted to hemlock as their food plant. Up to the 11th of July comparatively few other trees and shrubs were seen attacked by the looper. At the end of the larval period, end of July and first part of August, the number of other plants attacked increased steadily.

After the hemlocks, white cedar suffered most heavily from the attack of the looper. This is especially due to the character of the feeding on this tree. The small twigs are not devoured completely but cut through about ½ to 1 inch below the end. Under heavily infested white cedar, the ground was covered with these small cuttings. On Governor's Island white cedar trees were defoliated to such a degree that their recovery is very doubtful.

Feeding on white pine was less important, but very typical. The needles are attacked from the side, and are usually not bitten through. Some very thin strands are left, which dry up, curl and give the branches a very characteristic appearance.

Juniper, spruce and the few larches seen, were attacked in the same way as hemlock. On hardwoods, irregular cuts of all sizes and shapes are made in the leaves. In some of the rearing experiments the looper larvae attacked the upper surface of the leaf-veins of different maples.

It was not possible to determine exactly which hardwoods are preferred by the looper. There was considerable variation in this respect on different islands and at different times of the season. Oaks, maples, wild cherries and blueberries were the species most commonly attacked. It was estimated that no hardwood tree lost more than about 1/20 of its leaf surface. Blueberries were the only broad-leaved plants which were completely defoliated. This was noted on several islands.

After heavy wind and rains a great percentage of the larvae are blown down from the trees. These larvae, on reaching the ground, seek the nearest tree, regardless of species, and begin at once to climb the trunk. To determine the percentage of larvae thus coming to the ground either by accident or through some other urge, 50 trees on the northwest corner on Bell Island were banded with tanglefoot on July 6. Fifty-one twig samples were taken from these and many surrounding trees on July 17. The average number of larvae per 2 foot twig on unbanded trees was 21.7 whilst the banded trees showed a population of 14.45 larvae per twig. This would indicate a difference of 20.06% in total population. This percentage would probably have been much higher had the experiment been started before the hatching of the larvae and carried on to the end of the season. The banding of trees may, therefore, be helpful in reducing the infestation on small areas.

*The Pupa* (Plate I, Figure 2).—Fresh pupae are light green to yellowish-green in colour, when 36 to 48 hours old they assume their final colouring which is yellowish-brown with darker markings. The length varies from 11–16.5 mm., the average of 50 measurements being 13.76 mm. In width they measure from 3.08 mm. to 4.22 mm. with an average of 3.51 mm. for 50 specimens.

In nature the first pupa was found on August 2, one day before the first pupa was obtained from cage experiments. From that time the number of pupae found and reared increased daily. Pupation was still observed on September 20, but in a few cases only. The maximum number of pupae occurred in nature during the first days of September.

Dr. Fracker found that in Wisconsin the majority of the looper larvae pupate on the trees in crevices of the bark. In the region of the Muskoka Lakes only a small percentage pupated on the trees. Before and after the finding of the first pupae, trees were climbed and examined carefully. On smooth barked trees, either no pupae at all or such a small number only could be found as to be negligible. Rough barked trees had a higher population and pupae were seen on all parts of the trunk over 2½ inches in diameter. Crevices, loose bark and angles between the roots are the preferred places for pupation. However, more than 80% pupated on the ground, under fallen leaves, branches, small stones, in the moss and the debris. The larvae do not enter the mineral soil to pupate. On very hard ground where undergrowth is lacking and which is covered with a thin layer of duff principally composed of needles, they pupate on the surface. Buildings of any kind attract great numbers of larvae at the time of pupation. The greatest number of pupae per square yard was collected in a place protected by the overhanging of a roof. In this situation 176 fresh pupae, 2 prepupae, 1 full grown parasitized larva, 21 empty pupal skins from which moths and parasites had emerged, and 4 full grown dipterous parasite larvae were found giving a total population of 204. Such a high population is exceptional and must probably be ascribed to the protection offered by the roof. Similar figures were obtained from localities where old shingles, boards and pieces of loose bark were strewn about.

To determine the length of the pupal period, larvae and prepupae were collected and placed in vials. The first adults were obtained on the 18th day after pupation. Twenty-six days was the longest pupal period observed. In the majority of cases the pupal stage lasted between 20 and 24 days.

*The Adults* (Plate I, Figure 3, a–b).—In the laboratory the whole act of emergence including spreading of the wings lasted from 1 to 2 hours.

The first moths were seen in nature on August 18 on Cameron Island. On August the 19th, moths were seen on Loon Island and in the rearing experiments the first moth emerged on August 20. For a long time no females could be found in nature. From time to time collections were made to determine the sex ratio. Three hundred to five hundred moths were used for each count with the following results:—

| | | | | | |
|---|---|---|---|---|---|
| Aug. | 31 | Females | 3.6% | Males | 96.4% |
| Sept. | 4 | Females | 2.6% | Males | 97.4% |
| Sept. | 6 | Females | 6.0% | Males | 94.0% |
| Sept. | 11 | Females | 7.6% | Males | 92.4% |
| Sept. | 12 | Females | 11.7% | Males | 88.3% |
| Sept. | 13 | Females | 13.3% | Males | 86.7% |
| Sept. | 14 | Females | 13.5% | Males | 86.5% |
| Sept. | 19 | Females | 28.0% | Males | 72.0% |

In the rearing experiments the number of males greatly exceeded that of the females, 32.4% being females against 67.6% males. In the laboratory male emergence commenced on August 20, increasing gradually from August 25 and reaching its peak between September 3 and September 11. After the 19th of September only few males emerged. The number of emerging females began to increase 8 days later than that of the males, (September 2). The emergence reached its height between September 6 and 23. A small percentage of females was still emerging in the beginning of October. The belated emergence of the females explains the long lapse of time between the finding of the first moths and that of the first eggs.

The moths were plentiful and were found resting on trees and shrubs. They seek places which give a certain amount of protection against the weather.

During the morning hours the moths are quiescent, about noon they become slightly active, the period of their greatest activity being the evening hours.

Males kept in preserving jars and fed with sugar water lived up to 11 days, females up to 12 days.

In captivity the moths mate on the day of emergence. In some cases mating lasted from 4 to 10 minutes, in others more than an hour.

Some freshly emerged pairs were put in preserving jars with small hemlock twigs and pieces of bark for the study of oviposition.

The total number of eggs per female varied considerably although all the females were kept under the same conditions. The lowest number of eggs per female was 41 the highest 148. The average number of eggs per female, as based on these experiments, was 100.3.

## Control

### NATURAL ENEMIES

*Predators.*—The predators seemed to be of minor importance in checking the looper infestation in the Muskoka region. A very few Carabids were noticed feeding on the larvae of *Ellopia.* Three different hemipterous predators were also found. These were determined by Mr. G. Stuart Walley as: *Phytocoris angustatus* Reuter, *Podisus maculiventris* Say, and *Podisus serieventris* Whler.

*Parasites.*—*Diptera.*—Four Dipterous parasites were reared from collected material and were determined by Mr. C. H. Curran as: *Winthemia* sp., *Lydella eufitchiae* Towns, *Erycia rutila* Meig, and *Madremyia saundersoni* Williston.

Probably the most important of these in the Lake Joseph region, was *Winthemia* sp.

Dipterous eggs were found on 7.04% of a number of larvae collected in different places on or before August 9, whilst pupae collected at the end of the season on Loon Island and Bell Island showed a parasitism by Diptera of 8.25% and 5.20% respectively.

*Hymenoptera.*—Eight different species of Hymenoptera attacked the hemlock looper in 1928: *Campoplegidea ellopiae* Walley, *Itoplectis conquisitor* Say, *Ephialtes pedalis* Cresson, *Amblyteles velox* Cresson, *Zele* sp., *Pteromalus puparum* L, *Hemiteles* sp., and *Dibrachys* sp.

*Campoplegidea ellopiae* was described as a new species by Mr. G. Stuart Walley in the Canadian Entomologist, Vol. LXI, p. 22, 1929. The other species were determined by Messrs. A. B. Gahan and R. A. Cushman of the United States National Museum.

An idea of the parasitism in 1928 in the Muskoka Lakes district may be gained from the conditions existing on Bell Island, where out of 800 specimens 20.12% were found parasitized, 8.25% by Diptera and 11.75% by Hymenoptera.

## ARTIFICIAL CONTROL

When outbreaks of defoliating insects occur, the injury caused, especially to coniferous trees, is often fatal and it becomes imperative to have recourse to artificial control methods. In the case of broadleaf species the damage is usually not so severe and is confined to temporary disfigurement with, possibly, some loss of growth. Whether or not control measures should be applied to infested areas and to what extent the expenditure entailed is justifiable, will largely depend upon the valuation placed upon the trees. Control methods may be either *direct* or *indirect*. The first consist of emergency measures applied with a view to destroying the insects whenever they occur in outbreak form, whilst the latter, being mainly preventive in character, may be applied at any time and, if effective, should possess a more lasting value than the first.

*Direct Control Measures*.—1. Spraying or dusting with stomach poisons.—The hemlock looper being a leaf eating insect may readily be controlled by spraying or dusting the foliage of the infested trees with a stomach poison. There are several poisons which may be used effectively against the looper. Among these, arsenate of lead has the advantage of being simple in its application and safe against burning the foliage.

Spraying operations against the hemlock looper should be commenced as soon as the majority of the young larvae have hatched from the eggs. The period of hatching will probably vary somewhat from year to year and from region to region. For the Province of Ontario the most propitious time for spraying lies approximately between June 20 and July 15.

2. Banding the trees with sticky substances.—It is estimated that at least 30% of the loopers come to the ground at some time or another during the feeding period. If these larvae are prevented from returning to the foliage, at least a partial check of the infestation will result.

3. Dusting with airplanes.—The measures described above are applicable to small areas or isolated trees. When hundreds of acres are involved, the only effective, direct control measure is the distribution of poison dusts from airplanes. This method has been successfully applied against various insects in many parts of Europe and in 1926, it was used with good results against the hemlock looper in the state of Wisconsin. Dr. S. B. Fracker, who was in charge of these operations, states as follows: "It is estimated that in a solid hemlock stand the mortality was 90 to 95%, while in the mixed forest not less than 80%. In only one area which consisted of young hemlocks over-topped by deciduous trees and in another which was dusted just before a rain were the apparent results somewhat less than expected, with a mortality about 60%." (Jour. Econ. Ent. April, 1927).

Our own experience in Muskoka in 1928, although only a few acres were dusted, seemed to indicate that a considerable measure of success may be expected from airplane dusting, if done at the proper time.

Two areas were dusted on July 20, namely, Loon and Laurie Islands. The results of this operation were followed up as closely as possible. At the time of dusting most of the larvae had entered the fourth and quite a few the fifth stage of their development. There is not the slightest doubt that the dusting was begun at too late a date for good results. Experiments with larvae reared in preserving jars on very heavily poisoned material indicated quite conclusively that the larger larvae could withstand for a considerable time the effects of a much heavier doze than was possible or practical to apply by airplane.

Approximately 35 lbs. of calcium arsenate were used per acre. It was estimated that about 37% of the larvae were destroyed.

In 1929 airplane dusting was begun on June 19. Defects in the hopper mechanism caused several delays and regular operations were not possible until the 29th of June. The airplane used was a DeHaviland 61, equipped with a Jupiter 500 H.P. motor. It was in charge of Pilot Hector Ptolemy of the Ontario Provincial Air Service. The hopper was placed in the cabin and had a capacity of 1,400 lbs. It was made of three-ply and consisted of a rectangular box approximately 4 × 5 × 1½ feet, below which a rectangular funnel reached to the floor of the cabin. The opening through which the dust was released was 8″ × 22″ and was fitted with a slide operated by a system of levers from the cabin of the plane. During the dusting the mechanic operated the levers of the hopper mechanism at a signal received from the pilot. This arrangement had the advantage of relieving the pilot from the actual handling of the dust allowing him to give his entire attention to the manipulation of the airplane.

The agitator was of the sliding type, shaped somewhat like the frame of a wire letter-basket and connected to an eccentric gear mounted on the lower right wing of the plane where a small propeller furnished the driving power. This worked satisfactorily for a time, after which it was discovered that the vibration of the eccentric gear was gradually weakening the structure of the wing. When this was realized, the use of the agitator was discontinued and it was found that the delivery was not seriously affected. With the agitator in action 100 lbs. of dust was released in slightly over 9 seconds, with the agitator disconnected the delivery was reduced to 100 lbs. in 12.5 seconds. At no time was there any trouble from packing of the dust within the hopper.

The poison was undiluted calcium arsenate containing 40% of arsenic oxide. Two different brands were used, each having its own advantages and disadvantages. Fifteen minutes were required to put a load of fourteen hundred pounds into the hopper. Four men were employed for this task.

Practically all the dusting was done between 4 o'clock and 8 o'clock in the morning and between 5 o'clock and 8.30 o'clock in the evening. On some dull days, dusting was continued as late as 9 or 10 o'clock in the morning. It is believed that under the conditions prevailing in the Muskoka region, slightly better results were obtained from the evening dusting than from the morning operations. Usually, there was less wind between 7 and 8.30 in the evening than at any other time of the day, and dust applied late in the evening seemed to adhere better than that applied in the morning. This may perhaps be attributed to the action of night dews, the full benefit of which was received after an evening dusting.

The area to be treated comprised parts of the mainland and a number of islands on Lake Joseph as well as several islands in Lake Rosseau. A base was established at Footes Bay and all the infested stands lay within a radius of about 8 miles from this point in a region between 50 and 60 square miles in extent. In all about 1,000 acres of woodland were dusted. In many islands, where the hemlocks covered only a part of the total area, it was necessary to treat the entire island, because the air currents and winds made the exact laying down of swaths absolutely impossible. It happened not infrequently that the drift of a dust cloud was quite in the opposite direction from the one that might be reasonably anticipated. In laying each consecutive swath the pilot was obliged to guide himself by the effect of the preceding one. As the individual areas treated were comparatively small, this could be done quite satisfactorily.

Owing to these conditions we could not determine with accuracy the amount of dust placed on any one area. Theoretically, 30 lbs. per acre was the dose aimed at in heavily infested areas. Some of these, or parts of them may have received more, others less.

Aerial photographs and large scale maps were used in determining the limits of the areas to be dusted. Owing to the nature of the region and the location of all important stands near the edge of the water, it was a simple matter to find distinct landmarks by which the pilot could be guided in his work. No flags or other markers to indicate flight lines were used. The area of a forest being estimated and the dose to be applied being decided upon, the details of the actual dusting had to be left almost entirely to the judgment of the pilot. In all areas examined, the distribution of the poison was very satisfactory. The results in caterpillar mortality were equally gratifying. In one case, where a heavy rain followed six hours after the dusting, the mortality amounted to about 80%, some forty-eight hours after the application of the poison. In areas where the dust remained undisturbed for 24 hours, a mortality of 90% to 100% was the rule.

According to reliable reports, no moths were seen in the region in September, 1929. The complete disappearance of the pest must not be attributed solely to the dusting operations. The disappearance was general in treated and untreated areas. Nevertheless, a considerable amount of damage to valuable stands of hemlock was undoubtedly forestalled by the application of the dust. All the most heavily infested territory was carefully dusted, and, it is not at all improbable that this timely treatment may have contributed considerably to an early eradication of the loopers in the Muskoka region.

*Indirect Control Measures.*—As has been stated in another part of this paper, stands with a higher percentage of hemlock constitute natural foci for infestations by the hemlock looper. It would appear logical, therefore, that the gradual elimination of such stands would ultimately result in the production of a forest immune to attack by the looper. Wherever cutting operations are contemplated, the plan to be adopted would be the one which would bring about the production of a mixed stand. Local conditions must determine the method of procedure and the advice of a competent forester should be sought on these matters. In this connection the recommendations made by J. M. Swaine in Pamphlet No. 97, Dominion of Canada, Department of Agriculture, in the case of the infestation in the balsam stands of Newfoundland in 1925, are of outstanding interest.

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## RESUME

Notes sur l'arpenteuse de la pruche de l'Est (*Ellopia Piscellana* Gn.,) et sur les espèces alliées. J. J. De Gryse, Division de l'Entomologie, Ministère de l'Agriculture, Ottawa, Ont.

Depuis 1882 on a signalé à maintes reprises la présence, en nombre destructeur, au Canada et aux Etats-Unis, des membres du genre *Ellopia*. Il est parfois difficile d'établir l'identité exacte de l'espèce qui est responsable de ces invasions. Il est probable que l'espèce qui se rencontre généralement dans l'Est du Canada est le *Ellopia fiscellaria* Guen. Cet insecte pullulait dans la région de Muskoka entre les années 1924 et 1929, où il a détruit des peuplements précieux de pruche (*Tsuga*) dans bien des parties de cet endroit de villégiature. Son cycle évolutif est le suivant: les œufs sont pondus vers la fin d'août et pendant tout le mois de septembre. L'insecte hiverne dans l'œuf. Les larves éclosent vers le 10 juin. Il paraît y avoir cinq phases larvaires. La transformation en chrysalide se fait en août et l'insecte parfait vole vers la fin d'août et dans le mois de septembre. Les mâles commencent à faire leur apparition quelques jours avant les femelles.

La larve dans le district de Muskoka se nourrissait principalement sur la pruche mais à mesure que la provision de son aliment végétal préféré diminuait, elle s'attaquait à presque toutes les autres espèces d'arbres et d'arbustes, à l'exception cependant de l'if, *Taxus canadensis* Marshall. L'arpenteuse de la pruche compte un grand nombre d'ennemis naturels mais l'effet que ceux-ci ont exercé sur l'invasion a été insignifiant. On est parvenu à s'en rendre maître au moyen de saupoudrages par aéroplane en 1929. La mortalité directement attribuée à l'empoisonnement à l'arséniate de calcium s'est montée à plus de 90 pour cent.

# THE ECONOMIC IMPORTANCE OF PARASITOLOGY

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It is difficult to define, accurately and succinctly, a parasite. For our present purposes however, we may consider it as an organism which lives in, or on, another organism. As this would include vegetable organisms such as bacteria and fungi, which, by common consent, are now allocated to the separate sciences of bacteriology and mycology, we may alter our definition to "an animal which lives in, or on, other organisms." This definition of animal parasites is purposely vague and takes no heed of pathogenicity; this is deliberate, as we cannot always say which parasites are harmful, which are neutral and which are actually doing good to the host in which they live. We may, it is true, define as pathogenic, a parasite which causes some alteration, chemical or physical, *no matter how slight,* in the host tissue, but there is a large residuum of forms which produces no alteration which we have yet been able to detect, while in some cases, there is evidence to suggest that the parasites are actually helping in the host's economy.

Parasitism is a mode of life and is not the prerogative of any one group of animals; every group in the animal kingdom contains some parasitic members but those most prolific in parasites are the protozoa, the arthropods, and the flat and round "worms."

The protozoa are single-celled, usually microscopic, animalcules, with innumerable free-living but quite a few parasitic forms. These include the parasites of malaria, sleeping-sickness, red-water in cattle, coccidiosis and of many other diseases. The arthropods are mostly external parasites and their importance lies in their ability to carry infecting organisms from one host to another—the biting flies, mosquitoes, lice, fleas and ticks all function in this way. But this group does contain a number of true internal parasites, such as the warbles of cattle and the bots of horses, which are of very considerable economic importnce. The remaining two groups are often grouped together under the name of *helminths* or parasitic worms, but the flat-worms are quite separate from the round-worms, except in their choice of an environment. While, like both the previous groups, they contain many free-living forms, a large proportion is now entirely parasitic, no longer capable of living a free life apart from the host.

Parasitism always leads to specialization on the part of the parasite. Unused organs degenerate, used organs become enlarged or more efficient. The host supplies food and warmth, so that, in the internal parasites at least, there is a corresponding degeneration of the appendages and locomotion organs. At the same time, their generative mechanism is increased and the number of offspring multiplied enormously. This is because of the increased hazards of passing from one host to another. Many young parasites fall by the way and only a few survive to continue the race. In the course of evolution, the number of offspring produced by an adult parasite has been adjusted to meet the probable death-rate so that, *under natural conditions*, the egg or embryo output may be taken as inversely proportional to the chances of reaching a host. If this were not so, the parasite would either have died or would have multiplied to such an extent as to exterminate the host—and one of the fundamental tenets of parasitism is that the host should *not* be unduly harmed.

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[2] The Institute of Parasitology has been established with financial assistance from the Empire Marketing Board, the National Research Council of Canada and the Province of Quebec, and is directed by an Associate Committee of the National Research Council. It will be formally opened on June 27, 1934.

Except for the occasional case of intra-uterine infection, it is obvious that at least some part of the life of the parasite, must be passed outside of the host. This may be an adult or a larval stage—it varies considerably, but it is always constant for any given species, for parasitism is a well-regulated mode of life, governed by strict laws. Whatever stage it is, it is usually the weak link in the life-cycle and that at which the parasite can most successfully be attacked.

The protozoan parasites once they gain entrance to the body, can multiply almost indefinitely—coccidia are probably an exception to this rule, but even they can multiply to a considerable extent within the host. This means that the introduction of a single protozoan may be sufficient to cause disease, because disease always depends on numbers. In the case of the other parasites, no such multiplication within the body is possible and a single form introduced into the body remains single. It may give rise to innumerable offspring but all of these must leave the body before they can develop fully; there are no successive generations within the same host. This is a fundamental difference between the two groups. The protozoa resemble the bacteria in their methods of multiplication and attack on the host, although it is much more complicated. The remaining parasites—the Metozoan parasites as they are often called—are quite different.

Every species of vertebrate carries parasites of some sort—often a number of different species. These parasites do not, as a rule, do any great harm to their hosts. Their infective products are so widely scattered and meet such different conditions, that few of the young worms reach a host. Moreover, these parasites are all more or less specific, *i.e.*, they can develop only in a single species, or a group of closely related species of hosts. There are exceptions to this rule, however, and some of our most serious pests are among those exceptions; in general, however, the rule is true. Accordingly, the young of a sheep parasite, for example, if swallowed by, say, a horse, will not develop. These two facts explain why, although parasitism is universal, parasitic disease is not.

But, if animals (including human beings) become segregated, the infective larvae are concentrated; more and still more reach the host and develop; more eggs and embryos are passed and so the vicious circle proceeds until a state of hyper-parasitism is induced and disease and death results. This segregation may be natural, as in the great herds found in the tropics of Africa; zebra, rhinoceros, and elephants are very heavily parasitized. We see examples of it here in the "cycles" of rodents and carnivores which take place at fairly regular intervals. Owing to favourable conditions certain species of rodents increase abnormally in an area. Because of overcrowding, disease inevitably breaks out and the numbers are decimated. In due course the survivors cause another increase and so the cycles proceed. Among the major causes of these outbreaks, must be included the various internal parasites. Sometimes herd migration protects to some extent against this hyper-infection; it is just possible that the annual migration of the North American Bison in the past permitted the herds to keep their parasites at a low ebb. A similar result is seen in animals which normally live in dens; the large cats carry a terrific parasitic burden and even such temporary habitations as birds' nests may induce a heavy infection. But as a rule segregation is artificial and the result of man's interference—either intentional or unintentional. It was intentional when he domesticated his animals or confined them in zoos or national parks; it was unintentional when he exterminated carnivores and allowed their prey to multiply, or when, by drainage and settlement, he forced birds to congregate in limited spots. He has further intensified the result of this segregation by improving means of communication so that parasites, along with their hosts, might be easily moved from one locality to another, quickly and with a better chance of successful establishment in their new environment. Let us examine what has happened and is even now happening in this respect.

The first animal to become domesticated was man himself and parasites quickly became of supreme importance in public health. Some of these parasites came from his own simian ancestors; most came from the animals he learned to tame and keep close at hand. Those bands of men who moved into temperate climates lost a number of their parasites as climatic conditions were unsuitable or as advancing civilization brought in its trail effective methods of cooking, of sanitation, of cleanliness. In civilized countries nowadays, parasites are not very common, although they do occur and parasitic disease breaks out when the least chance is given it—witness parasitic infestations seen during the late war. In the tropics it has been quite otherwise. Millions of persons are still parasitized. Malaria is still the greatest killing disease in the world; flea-carried plague annually claims its hundreds of thousands of victims; hookworm infects 60% of the earth's population and is the most important of all Imperial diseases. The great diseases of the tropics are mostly parasitic; those of temperate climates are mainly bacterial.

None of the common domesticated animals is free from parasites and all carry some of tremendous importance. The dog—probably the oldest of all—suffers severely in puppyhood from ascarids and hookworms—and these attack him from the Tropics to the Arctic. After distemper—which is even now rapidly losing its menace under scientific investigation—ascarids are the most serious of all conditions in dogs. He carries however, a large number of other parasites, which are of lesser importance only because they are more limited in their distribution.

The silver fox, the most recent of man's experiments in domestication, suffers severely from a variety of parasites. Ascarids and hookworms are among the most serious of these and many a fox-farm in Canada has been put out of business by lung-worms alone.

Cats too, suffer from practically the same parasites as do dogs, although there are quite a number of differences, and they are responsible for considerable losses in these animals.

Horses are more heavily parasitized than any other animal and practically none is free. The horse came from the dry Steppes where his parasites had learned to resist all sorts of adverse influences, such as cold and drying, and yet survive. We put him on a moist, confined field or in a warm stable where conditions for the growth of the parasites are as nearly ideal as possible and the result has been a gross state of infestation. Now that most of the major bacterial diseases of horses are held in check, parasitism has become far and away the most important of all pathological conditions in these animals.

Sheep are in as bad a condition. It is doubtful if a single animal is free from parasites and there is no doubt whatever that they form by far the most serious source of loss to sheep farmers.

Cattle, on the whole are less seriously infected with worm parasites than are sheep. Their mode of feeding probably helps to keep these down. They do however, harbour some quite serious parasites, of which warbles are the most important.

The greatest source of loss in pigs is the large roundworm and this single species causes losses of millions of dollars yearly.

In poultry, only Bacilliary White Diarrhoea is more important than Coccidia and worms.

It is obvious, therefore, that parasitism is a serious, an appallingly serious, source of loss to stock owners. The fact that the effects of parasitism are gradual and slow in appearance makes the condition the more serious because farmers seldom suspect what it is that is gradually sapping their animals' condition, reducing their yield, hampering their natural increase and turning what should be a highly profitable industry into a most unsatisfactory business. They are familiar with the other sources of loss—nutritional and bacterial diseases. Modern research has placed the science of feeding on a sound basis and no farmer need fear the effects of unbalanced rations, or lack of vitamins or salts. Science has also laid the spectre of the great bacterial diseases, and most of these have already been conquered. But it is only in very recent times that people have come to realize the insidious, cumulative and constantly acting effects of parasites. In olden days they were probably not too great, although some, like liver-rot in sheep, have always claimed a heavy toll. It is only in modern times that they have reached serious proportions—and they are continually increasing as scientific agriculture makes it possible to keep more and more stock or any given piece of ground. The dictum that he is to be praised who makes possible two blades of grass where before only one grew, must be accepted with the greatest caution, at least so far as parasites are concerned. Thus, if a single infected sheep is confined on any given area of ground, it continually spreads worm eggs over that area. These eggs give rise to infective larvae in a week or so and are swallowed. Each one swallowed becomes adult and produces a new lot of eggs—several thousands at least. These are passed out and in due course, swallowed. If the area is small, more infective stages are swallowed; and the the smaller the area, the greater the degree of hyper-parasitism. Moreover, the sheep is compelled to continuously graze this area, thereby still further increasing the degree of infection.

So far I have been considering only domesticated animals. That is only part of the problem. Medicine has just discovered a new means of research which is called Comparative Medicine, by means of which the processes of disease are studied in all kinds of animals and even in plants. Parasitology discovered this method long ago and the study of the parasites of wild animals has been of immense service. Not only have valuable clues been found in that way—Leuckart discovered the life cycle of the guinea-worm by working on an unrelated fish round-worm—but many of these wild animal parasites have been found to be transmittable to man or domesticated animals. In these cases the new host is often less tolerant than the old and more acute disease results. For example, African sleeping sickness of man and Tsetse-fly disease (or N'gana) of stock, is caused by a parasite of antelopes in which it causes no disease at all. Many of the round-worms of wild animals have been, and still are being, passed to domesticated forms, as man opens up new districts and introduces his own stock. This has actually occurred in Canada where a variety of forms in native ruminants have been acquired by our introduced domestic species, with very serious results.

Among other things, we find that both wild ruminants and wild carnivores act as intermediate hosts for various important human and stock worms. Moose, for example, are often infected with Hydatid cysts. These give rise to tapeworms when eaten by carnivores, which in turn may affect man with the cysts. Various wild carnivores, such as bears, often carry the Trichina worm; the flesh of such animals eaten by human beings in an undercooked or "jerked" condition can transmit the parasite to man. These two parasites by the way, are among the most serious from which human beings can suffer and it is of great importance to realize that both are present in the Dominion.

Even when they do not harbour such forms, the parasites of wild and game animals are important in themselves. Canada, with its numerous national parks and game reserves, is carrying out a system of segregation—and the usual results are accompanying this. Carnivores have been exterminated or reduced in numbers, the other animals have been allowed to multiply freely in "sanctuaries"—and parasitism has increased enormously. As Mr. Hoyes Lloyd once remarked to me "Killing-off carnivores, is one method of exterminating the other wild animals on which they prey." We can see an excellent example of this in the Red deer in Scotland. Artificial protection and the absence of all natural enemies except man, has permitted an enormous increase in numbers in the Scottish Deer Forests. The animals have decreased in quality and in size and parasitism is rife. Unless numbers are artificially decreased in the near future, that once magnificent animal is going to disappear completely. Similarly, artificial propogation and the protection afforded by the destruction of small vermin and the imposition of closed seasons, has led to serious parasitic diseases among grouse and partridges, and numbers have increased beyond the capacity of the hills and moors to support. Protection may defeat its own ends.

When agriculture advances into the wild spaces, drainage systems reduce the water area available for use by ducks and other aquatic birds; overcrowding of such lakes as are left results, and parasitism increases. Artificial bird sanctuaries are equally dangerous unless great care is taken. Disease is proportional to the numbers which congregate in them. Moreover, birds are forced to seek new forms of food and may acquire new forms of parasites, which are always more serious than their own proper ones. We actually have seen examples of this happening in Canada.

Zoos are likewise dangerous, and we have many examples of outbreaks of parasitic disease there when over-crowding takes place and sanitation is not too good. The rearing of fur-bearing animals in captivity is an industry which is just beginning in Canada. Each ranch is in the position of a miniature zoological garden and the same results follow. I have already mentioned the case of the silver fox: the others are similar and the work of Law and Kennedy in Ontario together with our own investigations at the Institute of Parasitology, shows that all the fur-bearers carry many parasitic worms.

Among fish too, many are found heavily parasitized and quite a number of both human and animal worms are carried from host to host by these animals. Examples include the broad-tapeworm of man, which is attracting considerable attention around the Great Lakes and in Manitoba, and the liver-fluke of dogs which we are finding is not uncommon in our own North Country.

Parasitology then is a subject of enormous importance, not only to Canada but to the rest of the British Commonwealth and the world in general. Its study has permitted the opening of the tropics and is making them safe for the white man. If less important in temperate climates to human beings personally, they are more important to his stock—stock in the tropics is, on the whole, widely scattered. They are the greatest source of loss in horses, sheep and pigs; they cause millions of dollars damage annually to cattle; they are very serious pests in poultry, dogs, foxes and cats. They are equally serious in captive wild animals on ranches and in zoos; they can do great damage in national parks and they play a considerable part in the mechanism of the cycles of rodents and fur cycles. All this is the more important because bacterial and nutritional diseases are on a fair way to be brought under complete control.

The Veterinary Public Health Service has done much to bring this about and in no country is it more efficient than in Canada. Watson's epoch-making work here abolished dourine in horses; most of the great epizootic plagues have been banished from the Dominion while bovine tuberculosis is on a fair way to being exterminated; but as yet we have taken few steps to control the parasitic diseases. I am well within the truth when I say, that parasitism is now by far the most important condition in our stock. I must not be interpreted as saying that Canada has not produced any one interested in Parasitology—I have only to mention such names as Osler, Evans, Todd, Watson and Hadwen to refute that suggestion—but few attempts have yet been made at control.

This is the state of affairs which led to the establishment of the Institute of Parasitology in McGill University at Macdonald College. The initiative came from the National Research Council and it was supported, in its beginning, by the Empire Marketing Board, as it was realized that the subject is one which affects the whole British Commonwealth. The Institute is governed by a joint committee of the National Research Council and the University, with the President of the Council as its Chairman. As Director of the Institute, I hope I may be allowed to say, that it is owing to the more than sympathetic control by that Committee that the work of the Institute is progressing so smoothly. All concerned have co-operated in every way to make this possible, as indeed have innumerable Government Departments, both federal and provincial, and many other public bodies and corporations. This co-operation makes the future work of the Institute most promising.

We have divided our work into three divisions which have no very hard and fast lines between them: information, research, and teaching.

At present the last is the least important and only post-graduate students are received. Two parasitology degrees have been instituted at

McGill—an M.Sc., and a Ph.D.—and while only a very few students are under instruction at present, as the accommodation is increased and as recovery advances, there will be more. In parenthesis, I might mention that the Institute has one of the most representative teaching collections of parasites available anywhere.

Research is our most important activity and we have divided this into four groups: zoological (dealing with identifications, systematics and bionomics of parasites); veterinary (dealing with pathology and therapeutics); agricultural (dealing with control measures); and biochemical (dealing with the physiology of parasites and host resistance). At present these divisions are not in full activity but as the staff increases, the present workers will become more specialized. In addition to this, all members of the staff are engaged on a survey of the parasites of animals in Canada. This is mainly, but by no means exclusively, concerned with economically important animals and is the first comprehensive attempt ever made to place knowledge of the the parasites in a country on a strictly scientific basis. In this survey, we are receiving a great amount of assistance from various government departments (especially the Health of Animals Branch, the Parks Branch, the North West Territories Branch, the Royal Canadian Mounted Police, the Department of Indian Affairs and the National Museum), as well as from the Hudson's Bay Company and other private corporations and individuals throughout the Dominion.

The information Service is rapidly completing its organization. We have a small but useful library in the Institute supplemented by a card index summary of all papers on parasites published since January, 1932. We are receiving great assistance from the Imperial Bureau of Agricultural Parasitology in England and from the Information Division of the National Research Council. In this way, we are utilizing what has already been published elsewhere in solving our own problems and in keeping our agriculturists informed of what steps even now may be taken to reduce losses due to parasites.

The Institute, as I mentioned above, while primarily Canadian in its outlook, does not propose to be exclusively so. It was intended to help in the work throughout the whole Empire and it is already receiving material from many other parts abroad, especially from Bermuda, the West Indies and British Guiana which, as you know, are of especial interest to Canada.

Our present plans are also our future ones. As the present building, which has been donated by the Quebec Government, is enlarged and as funds become available, we hope to develop the work along the lines I have mentioned above. Canada, with its wide geographical and climatic conditions, is eminently suitable for this type of work, and we hope that soon it will lead the Empire.

My friend and colleague, Dr. Maurice C. Hall, Chief of the Division of Zoology of the U.S. Bureau of Animal Industry, in discussing parasitism, recently declared that mankind is losing the war against live-stock parasites. While this is true, we have by no means lost it yet. The war has really only now commenced. We believe that the fundamental work which is being done will provide much needed ammunition and that once the public is aroused to the insidious and dangerous nature of the "enemy within our gates," it will order a general mobilization and quickly bring these parasites within effective control.

# SIGNIFICANCE DETERMINATION NUMBERS

## NUMBERS OF INDIVIDUALS REQUIRED AT DEFINITE ODDS TO SECURE STATISTICAL SOUNDNESS IN EXPERIMENTAL TRIALS

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[Received for publication May 10, 1934]

The table here presented shows the number of individuals necessary, in each of two experimental groups, to reduce the probability of any given difference occurring by chance alone to five per cent (P = .05). The coefficient of variability, as well as the difference which it is desired to demonstrate, must be known. Conversely, given a definite number of individuals for two experimental lots, and with a reasonably safe estimate of the Coefficient of Variability to be expected, the necessary per cent difference that is required between the two mean observations in order to establish with odds of 19 to 1 that such difference is due to the experimental treatment accorded them and not to chance alone, may readily be determined from this table.

The table shows the necessary number of individuals left for comparison at the end of a test. The numbers required at the beginning will consequently have to be increased proportionately to any losses that may be expected to occur during the test.

The single units of such lots will necessarily have to be drawn from the same universe, and will consequently, in probably all cases, have to be of the same sex, as sex-different response to experimental treatment would produce either a bimodal or a skew distribution, to which the ordinary measures of variability could not be applied.

Determination of the numbers required was derived from the formula for the Standard Error of the difference

$$\sigma_d = \sqrt{\frac{\sigma_1^2}{N_1} + \frac{\sigma_2^2}{N_2}}$$

and from the $\frac{\bar{x}}{\sigma}$ value for the odds required. These calculations were checked by the method employing the $t$ values of R. A. Fisher, *Statistical Methods for Research Workers* (1925. Oliver and Boyd). All numbers below 31 were calculated by this latter method.

A random calculation of the numbers required is given herewith, assuming a Mean of 300, a C.V. of 10, and a Difference between means of 4%.

$$M_1 - M_2 = 4\%\ M \qquad M_1 - M_2 = \frac{4}{100} \times 300 \qquad M_1 - M_2 = 12$$

$$\frac{\sigma}{M} \times 100 = 10 \quad \frac{\sigma}{M} = .10 \qquad \frac{\sigma}{300} = .10 \qquad \sigma = 30$$

TABLE OF NUMBERS OF INDIVIDUALS NECESSARY IN EACH OF TWO LOTS TO SECURE ODDS OF 19 : 1 THAT A DIFFERENCE BETWEEN MEANS IS NOT DUE TO CHANCE ALONE

DIFFERENCE BETWEEN MEAN OF EXPERIMENTAL AND CONTROL LOTS IN PER CENT: $\frac{M_1 - M_2}{\frac{M_1 + M_2}{2}} \times 100$

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **20** | | | | | | | | | | | | 7 | 7 | 8 | 8 | 9 | 10 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 20 | 21 | 23 | 24 | 25 | 26 |
| **19** | | | | | | | | | | | 6 | 7 | 8 | 8 | 9 | 10 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 20 | 21 | 22 | 23 | 25 | 26 | 27 | 28 |
| **18** | | | | | | | | | | 6 | 7 | 8 | 8 | 9 | 10 | 10 | 11 | 12 | 13 | 14 | 16 | 17 | 18 | 20 | 21 | 23 | 24 | 26 | 27 | 28 | 29 | 31 |
| **17** | | | | | | | | | | 7 | 8 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 21 | 22 | 24 | 25 | 27 | 27 | 29 | 31 | 31 | 32 |
| **16** | | | | | | | | | 6 | 8 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 18 | 20 | 22 | 23 | 25 | 26 | 27 | 29 | 31 | 31 | 32 | 34 | 36 |
| **15** | | | | | | | | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 16 | 17 | 18 | 21 | 22 | 24 | 26 | 27 | 28 | 30 | 31 | 32 | 35 | 37 | 39 | 41 |
| **14** | | | | | | | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 15 | 16 | 18 | 20 | 22 | 24 | 25 | 27 | 28 | 30 | 31 | 33 | 35 | 37 | 40 | 42 | 45 | 48 |
| **13** | | | | | | 6 | 7 | 8 | 8 | 10 | 11 | 12 | 14 | 15 | 17 | 18 | 21 | 22 | 25 | 27 | 28 | 30 | 31 | 33 | 35 | 38 | 41 | 43 | 47 | 49 | 52 | 55 |
| **12** | | | | | | 7 | 8 | 8 | 10 | 11 | 12 | 14 | 16 | 17 | 20 | 22 | 24 | 26 | 28 | 30 | 31 | 33 | 36 | 39 | 41 | 44 | 48 | 51 | 55 | 58 | 61 | 65 |
| **11** | | | | | 6 | 8 | 8 | 10 | 11 | 13 | 14 | 16 | 18 | 21 | 23 | 26 | 27 | 30 | 31 | 33 | 36 | 39 | 43 | 46 | 49 | 53 | 57 | 60 | 65 | 68 | 73 | 77 |
| **10** | | | | 6 | 7 | 8 | 10 | 11 | 13 | 15 | 17 | 20 | 22 | 25 | 27 | 29 | 31 | 34 | 37 | 40 | 44 | 48 | 51 | 56 | 60 | 64 | 68 | 73 | 79 | 83 | 88 | 93 |
| **9** | | | 6 | 7 | 8 | 10 | 11 | 13 | 16 | 18 | 21 | 24 | 27 | 29 | 31 | 34 | 38 | 41 | 45 | 50 | 54 | 59 | 63 | 68 | 74 | 79 | 84 | 90 | 97 | 102 | 108 | 115 |
| **8** | | | 7 | 8 | 10 | 12 | 14 | 16 | 20 | 23 | 26 | 29 | 31 | 34 | 38 | 43 | 48 | 52 | 57 | 63 | 68 | 74 | 80 | 87 | 93 | 100 | 107 | 114 | 123 | 129 | 137 | 146 |
| **7** | | 6 | 8 | 10 | 12 | 15 | 18 | 22 | 25 | 28 | 31 | 35 | 40 | 45 | 50 | 56 | 62 | 68 | 75 | 82 | 89 | 97 | 106 | 113 | 122 | 131 | 140 | 149 | 161 | 169 | 179 | 190 |
| **6** | 6 | 7 | 10 | 12 | 16 | 20 | 24 | 28 | 31 | 36 | 41 | 48 | 54 | 61 | 68 | 76 | 85 | 93 | 102 | 112 | 122 | 132 | 143 | 154 | 166 | 178 | 190 | 203 | 219 | 230 | 244 | 259 |
| **5** | 7 | 10 | 13 | 17 | 22 | 27 | 31 | 37 | 44 | 51 | 60 | 68 | 78 | 88 | 99 | 110 | 122 | 134 | 147 | 161 | 175 | 190 | 206 | 222 | 239 | 256 | 274 | 292 | 315 | 331 | 352 | 373 |
| **4** | 10 | 14 | 20 | 26 | 31 | 39 | 48 | 58 | 69 | 80 | 93 | 107 | 122 | 138 | 154 | 172 | 190 | 210 | 230 | 252 | 274 | 297 | 322 | 347 | 373 | 400 | 428 | 457 | 493 | 518 | | |
| **3** | 15 | 24 | 31 | 41 | 54 | 68 | 84 | 102 | 121 | 143 | 165 | 190 | 216 | 244 | 273 | 304 | 337 | 372 | 408 | 446 | 486 | 527 | | | | | | | | | | |
| **2** | 31 | 47 | 68 | 93 | 121 | 154 | 190 | 230 | 273 | 321 | 372 | 427 | 486 | 548 | | | | | | | | | | | | | | | | | | |
| **1** | 122 | 190 | 273 | 372 | 486 | 615 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** | **18** | **19** | **20** | **21** | **22** | **23** | **24** | **25** | **26** | **27** | **28** | **29** | **30** | **31** | **32** | **33** | **34** | **35** |

MEAN COEFFICIENT OF VARIABILITY: $\frac{\left(\frac{\sigma_1}{M_1} \times 100\right) + \left(\frac{\sigma_2}{M_2} \times 100\right)}{2}$

Necessary difference to give odds of 19 to 1 using the $\frac{\bar{x}}{\sigma} = 1.95$ value.

$$\frac{M_1 - M_2}{\sigma_d} = 1.95 \qquad \frac{12}{\sigma_d} = 1.95 \qquad \sigma_d = 6.15$$

$$\sigma_d = \sqrt{\frac{\sigma_1^2}{N_1}+\frac{\sigma_2^2}{N_2}} \text{ if } \sigma_1 = \sigma_2 \text{ and } N_1 = N_2 \text{ then } \sigma_d = \sqrt{\frac{2\sigma^2}{N}} \text{ or } N = \frac{2\sigma^2}{\sigma_d^2}$$

$$N = \frac{2 \times 30^2}{6.15^2} \qquad N = 47.55$$

*Check*

Necessary difference (*ND*) to give odds of 19 to 1 with *t* value of 1.95996 ($P = .05$ and $n = \infty$).

$$ND = \sigma_d \times t \qquad \sigma_d = \sqrt{\frac{\sigma_1^2}{N_1}+\frac{\sigma_2^2}{N_2}} \qquad \therefore\ ND = \sqrt{\frac{\sigma_1^2}{N_1}+\frac{\sigma_2^2}{N_2}} \times t$$

$$ND = \sqrt{\frac{2 \times 30^2}{47.55}} \times t \qquad ND = \sqrt{37{\cdot}85} \times 1.95996 \qquad ND = 12.05$$

$$\text{Per cent difference } \frac{12.05}{300} \times 100 = 4.017$$

An accurate check is thus obtained when consideration is given to the fact that $\frac{\bar{x}}{\sigma} = 1.95$ and $P$ at $n = \infty = .05$ are not exact opposites.

Our sincere thanks are due Mr. C. H. Schroeder and Mrs. H. B. Lawrence of the Larrowe Research Farm and to Mr. J. W. Hopkins of the National Research Council for helpful discussions.

## RESUME

LA SIGNIFICATION DES CHIFFRES DE DÉTERMINATION. S. Bird et H. S. Gutteridge, Service de l'Aviculture, Ferme expérimentale centrale, Ottawa.

Le tableau ici présenté montre le nombre d'individus qui est nécessaire dans chacun de deux groupes expérimentaux pour réduire à cinq pour cent (P = .05) la probabilité qu'une certaine différence soit produite par la chance seule. Il faut que le coefficient de variabilité, de même que la différence dont la démonstration est cherchée, soient connus. Par contre, admettant que l'on ait un nombre spécifique d'individus pour deux groupes expérimentaux, et une évaluation raisonnablement sûre du coefficient de variabilité, on peut aisément déterminer, d'après ce tableau, la différence nécessaire en pourcentage qui doit exister entre deux observations moyennes pour qu'on puisse établir, par des chances de 19 à 1, que cette différence est due au traitement expérimental dont ces groupes sont l'objet et non pas à la chance seule. Le tableau indique le nombre nécessaire d'individus laissés pour la comparaison à la fin d'une épreuve. Il faudra donc augmenter le nombre exigé au commencement, proportionnellement aux pertes qui peuvent se produire pendant l'essai. Les unités simples de ces lots devront nécessairement être tirés du même univers et devront, par conséquent, dans peut-être tous les cas, être du même sexe, car une réponse différente de sexe au traitement expérimental produirait une distribution bimodale ou oblique à laquelle les mesures ordinaires de variabilité ne pourraient être appliquées.

# INFLUENCE OF RUST INJURY ON THE VIGOUR AND YIELD OF TIMOTHY[1]

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[Received for publication March 23, 1934]

Among the factors which contribute to the successful adaptation of timothy in certain regions is the ability to resist a disease known as timothy rust, caused by *Puccinia graminis phlei-pratensis* (Eriks. & Henn.) S. & P.

Webber (*6*) and Piper (*4*) have regarded rust as "the most serious disease affecting timothy." Horsfall (*3*) has labelled it "a destructive disease," although he reviews a number of observations from different sources which reflect some diversity of opinion on the matter and suggest the need of further evidence.

## TIMOTHY RUST AT MACDONALD COLLEGE

A rather striking demonstration of the destructiveness of the disease was afforded during the late summer of 1932, when seasonal or local conditions, or both, seemed to provide an extra favourable environment for the development of the disease.

A total of 116 strains, collected from widespread North American and European sources, had been transplanted to the timothy nursery as individual plants in June of that year. The plants were spaced 30 × 32 inches apart, and the strains consisted of single 2-row lots of 50 (in a few cases 1-row lots of 25) plants each, with a common "check" strain at 35-foot intervals throughout the test. This material had been handled in a uniform manner both before and after planting and developed in a normal manner until the rust appeared.

Although the rust infection was distributed among plants throughout the entire test, it appeared more general in certain areas.

No survey was made to determine if more than one species of rust was responsible for the injury. Attention was focussed on the intensity of infection, as indicated by the development of rust pustules on the leaves, and the influence of the parasite upon the apparent vigour of its host.

In order to obtain some measure of the differential reaction of strains and of plants within strains to the rust disease, it was decided that each individual plant should be graded according to the extent of infection and resultant injury, as indicated in the following scale:

*Grades of Rust Injury, September, 1932*

0 = plant apparently free from rust;
1 = plant with slight amount of rust injury but with no pustules visible;
2, 3, and 4 = plants showing an increasing intensity of infection and rust injury;
5 = plant almost dead as a result of rust injury.

The frequencies within these grades for a large number of strains may be found in Tables 1 and 2.

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[1] Contribution from the Faculty of Agriculture of McGill University, Macdonald College, P.Q., Canada. Journal Series No. 39.

[2] Lecturer in Agronomy.

### TABLE 1.—INFLUENCE OF RUST INJURY ON THE VIGOUR OF TIMOTHY. IMPROVED AND REGIONAL STRAINS

| Designation of strain | Origin | Plants set out | Frequencies within grades of rust injury. Sept., 1932 | | | | | | Frequencies within grades of spring vigour. May, 1933 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 0 | 1 | 2 | 3 | 4 | 5 | 0 | 1 | 2 | 3 | 4 | 5 |
| F.C. 11891 | U.S.A. | 50 | 23 | 19 | 4 | 3 | 1 | — | 0 | 2 | 10 | 25 | 13 | — |
| F.C. 12454 | U.S.A. | 50 | 22 | 22 | 4 | 2 | — | — | 0 | 2 | 9 | 26 | 12 | 1 |
| F.C. 12468 | U.S.A. | 50 | 25 | 24 | 1 | — | — | — | 0 | 0 | 2 | 27 | 21 | — |
| Waldron | U.S.A. | 50 | 8 | 19 | 9 | 11 | 2 | 1 | 0 | 8 | 16 | 20 | 6 | — |
| F.C. 3937 | U.S.A. | 50 | 23 | 22 | 1 | 3 | 1 | — | 0 | 3 | 11 | 17 | 19 | — |
| Check | U.S.A. | 50 | 11 | 24 | 7 | 6 | 1 | 1 | 0 | 1 | 17 | 20 | 12 | — |
| F.C. 12368 | U.S.A. | 50 | 21 | 20 | 5 | 2 | 0 | 2 | 0 | 3 | 10 | 18 | 19 | — |
| F.C. 12365 | U.S.A. | 50 | 19 | 21 | 8 | 1 | 1 | — | 0 | 4 | 9 | 22 | 15 | — |
| F.C. 11791 | U.S.A. | 50 | 27 | 18 | 2 | 1 | 2 | — | 0 | 3 | 5 | 26 | 16 | — |
| Cornell No. 1777 | U.S.A. | 50 | 8 | 20 | 8 | 7 | 7 | — | 1 | 4 | 16 | 26 | 3 | — |
| Cornell No. 4059 | U.S.A. | 50 | 6 | 14 | 18 | 9 | 3 | — | 1 | 7 | 20 | 16 | 6 | — |
| Check | — | 50 | 8 | 20 | 8 | 7 | 7 | — | 1 | 4 | 16 | 26 | 3 | — |
| Φtofte | Denmark | 50 | 35 | 7 | 0 | 5 | 2 | 1 | 0 | 4 | 6 | 25 | 15 | — |
| Kampe I | Sweden | 50 | 13 | 6 | 10 | 7 | 11 | 3 | 2 | 14 | 18 | 13 | 3 | — |
| Kampe II | Sweden | 50 | 18 | 11 | 3 | 4 | 10 | 4 | 1 | 11 | 11 | 15 | 12 | — |
| Weihenstephan | Germany | 50 | 36 | 7 | 2 | 2 | 2 | 1 | 0 | 4 | 7 | 26 | 13 | — |
| Schivarzwald | Germany | 50 | 8 | 11 | 9 | 11 | 9 | 2 | 0 | 12 | 23 | 11 | 4 | — |
| Lischower | Germany | 50 | 32 | 12 | 2 | 2 | 2 | — | 0 | 0 | 15 | 27 | 8 | — |
| Check | — | 50 | 22 | 14 | 7 | 5 | 1 | 1 | 0 | 3 | 19 | 16 | 12 | — |
| Moravian | Cz'vakia | 50 | 15 | 15 | 7 | 4 | 8 | 1 | 2 | 12 | 6 | 26 | 4 | — |
| Lappi | Finland | 50 | 5 | 3 | 8 | 9 | 21 | 4 | 7 | 20 | 13 | 8 | 2 | — |
| P-586 | Finland | 50 | 16 | 8 | 8 | 13 | 5 | — | 0 | 14 | 17 | 12 | 7 | — |
| Check | — | 50 | 22 | 12 | 4 | 8 | 4 | — | 3 | 5 | 12 | 21 | 9 | — |
| Scottish | Scotland | 50 | 11 | 4 | 7 | 13 | 14 | 1 | 3 | 15 | 16 | 14 | 2 | — |
| S. 51 | Wales | 50 | 38 | 6 | 3 | 2 | 1 | — | 0 | 0 | 10 | 24 | 16 | — |
| S. 48 | Wales | 50 | 37 | 6 | 3 | 4 | — | — | 0 | 0 | 8 | 32 | 9 | 1 |
| Grindstad | Norway | 50 | 3 | 6 | 9 | 16 | 16 | — | 0 | 20 | 19 | 7 | 4 | — |
| Biskopsbole | Finland | 50 | 3 | 6 | 6 | 16 | 17 | 2 | 1 | 12 | 29 | 6 | 2 | — |
| Haukila | Finland | 50 | 8 | 5 | 11 | 8 | 17 | 1 | 0 | 7 | 27 | 12 | 4 | — |
| Check | — | 50 | 17 | 8 | 10 | 11 | 4 | — | 0 | 4 | 17 | 18 | 11 | — |
| Ekero | Finland | 50 | 8 | 6 | 3 | 12 | 15 | 6 | 1 | 11 | 24 | 9 | 5 | — |
| Gloria | Sweden | 50 | 29 | 5 | 4 | 7 | 5 | — | 0 | 3 | 10 | 16 | 21 | — |
| Bore | Sweden | 50 | 3 | 9 | 12 | 19 | 6 | 1 | 2 | 5 | 25 | 14 | 4 | — |
| Bottnia | Sweden | 50 | 4 | 3 | 6 | 12 | 22 | 3 | 2 | 13 | 23 | 6 | 5 | 1 |
| Check | — | 50 | 15 | 11 | 3 | 8 | 12 | 1 | 0 | 6 | 15 | 13 | 16 | — |
| All strains | — | 1450 | 504 | 335 | 173 | 205 | 200 | 33 | 23 | 213 | 415 | 526 | 270 | 3 |
| All checks | — | 300 | 95 | 89 | 39 | 45 | 29 | 3 | 4 | 23 | 96 | 114 | 63 | 0 |

### TABLE 2.—INFLUENCE OF RUST INJURY ON YIELD OF TIMOTHY

IMPROVED AND REGIONAL STRAINS

| Designation of strain | Origin | Frequencies within grades of rust injury. Sept., 1932 | | | | | | | Total green yields in ounces within grades of rust injury. 1933 | | | | | | | Average green yields per plant in ounces within grades of rust injury. 1933 | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 | 4 | 5 | Total | 0 | 1 | 2 | 3 | 4 | 5 | Total | 0 | 1 | 2 | 3 | 4 | 5 | Average |
| 508 | M.C. | 19 | 27 | 2 | 0 | 2 | — | 50 | 385 | 357 | 18 | — | 3 | — | 763 | 20.3 | 13.2 | 9.0 | — | 1.5 | — | 15.3 |
| 603 | M.C. | 16 | 30 | 2 | 1 | 1 | — | 50 | 286 | 550 | 22 | 4 | 1 | — | 863 | 17.9 | 11.9 | 11.0 | 4.0 | 1.0 | — | 17.3 |
| Check | U.S.A. | 22 | 18 | 6 | 2 | 2 | — | 50 | 400 | 267 | 76 | 13 | 8 | — | 764 | 18.2 | 14.8 | 12.7 | 6.5 | 4.0 | — | 15.3 |
| 710 | M.C. | 25 | 21 | 2 | 1 | 1 | — | 50 | 508 | 401 | 36 | 6 | 6 | — | 957 | 20.3 | 19.1 | 18.0 | 6.0 | 6.0 | — | 19.1 |
| 712 | M.C. | 31 | 11 | 4 | 2 | 1 | 1 | 50 | 676 | 211 | 45 | 14 | 3 | 1 | 950 | 21.8 | 19.2 | 11.2 | 7.0 | 3.0 | 1.0 | 19.0 |
| Check | — | 25 | 14 | 6 | 4 | 1 | — | 50 | 469 | 204 | 45 | 16 | 4 | — | 738 | 18.8 | 14.6 | 7.5 | 4.0 | 4.0 | — | 14.8 |
| 805 | M.C. | 26 | 21 | 0 | 1 | 2 | — | 50 | 589 | 430 | — | 9 | 10 | — | 1038 | 22.6 | 20.5 | — | 9.0 | 5.0 | — | 20.8 |
| 819 | M.C. | 24 | 19 | 3 | 1 | 2 | 1 | 50 | 587 | 409 | 46 | 11 | 9 | 1 | 1063 | 24.4 | 21.5 | 15.3 | 11.0 | 4.5 | 1.0 | 21.3 |
| Check | — | 18 | 20 | 6 | 4 | 2 | — | 50 | 429 | 345 | 41 | 28 | 7 | — | 850 | 23.8 | 17.2 | 6.8 | 7.0 | 3.5 | — | 17.0 |
| F.C. 12468 | U.S.A. | 25 | 24 | 1 | — | — | — | 50 | 426 | 352 | 6 | — | — | — | 784 | 17 0 | 14.7 | 6.0 | — | — | — | 15.7 |
| F.C. 3937 | U.S.A. | 23 | 22 | 1 | 3 | 1 | — | 50 | 386 | 260 | 3 | 21 | 2 | — | 672 | 16.8 | 11.8 | 3.0 | 7.0 | 2.0 | — | 13.4 |
| Check | — | 11 | 24 | 7 | 6 | 1 | 1 | 50 | 228 | 437 | 65 | 34 | 2 | 1 | 767 | 20.7 | 18.2 | 9.3 | 5.7 | 2.0 | 1.0 | 15.3 |
| F.C. 11791 | U.S.A. | 27 | 18 | 2 | 1 | 2 | — | 50 | 479 | 283 | 10 | 3 | 4 | — | 779 | 17.7 | 15.7 | 5.0 | 3.0 | 2.0 | — | 15.6 |
| Cornell No. 1777 | U.S.A. | 8 | 20 | 8 | 7 | 7 | — | 50 | 110 | 186 | 63 | 41 | 15 | — | 415 | 13.8 | 9.3 | 7.9 | 5.9 | 2.1 | — | 8.3 |
| Cornell No. 4059 | U.S.A. | 6 | 14 | 18 | 9 | 3 | — | 50 | 94 | 166 | 85 | 31 | 4 | — | 380 | 15.7 | 11.8 | 4.7 | 3.4 | 1.3 | — | 7.6 |
| Check | — | 8 | 20 | 8 | 7 | 7 | — | 50 | 110 | 186 | 63 | 41 | 15 | — | 415 | 13.8 | 9.3 | 7.9 | 5.9 | 2.1 | — | 8.3 |
| Φtofte | Denmark | 35 | 7 | 0 | 5 | 2 | 1 | 50 | 638 | 101 | — | 19 | 4 | 1 | 763 | 18.2 | 14.4 | — | 3.8 | 2.0 | 1.0 | 15.3 |
| Weihenstephan | Germany | 36 | 7 | 2 | 2 | 2 | 1 | 50 | 567 | 96 | 12 | 6 | 6 | 2 | 689 | 15.7 | 13.7 | 6.0 | 3.0 | 3.0 | 2.0 | 13.8 |
| Check | — | 22 | 14 | 7 | 5 | 1 | 1 | 50 | 332 | 174 | 32 | 14 | 3 | 1 | 556 | 15.1 | 12.4 | 4.6 | 2.8 | 3.0 | 1.0 | 11.1 |
| Lappi- | Finland | 5 | 3 | 8 | 9 | 21 | 4 | 50 | 80 | 40 | 33 | 21 | 21 | 0 | 195 | 16.0 | 13.3 | 4.1 | 2.3 | 1.0 | 0.0 | 3.9 |
| Check | — | 22 | 12 | 4 | 8 | 4 | — | 50 | 371 | 128 | 13 | 26 | 6 | — | 544 | 16.9 | 10.7 | 3.2 | 3.2 | 1.5 | — | 10.9 |
| S. 51 | Wales | 38 | 6 | 3 | 2 | 1 | — | 50 | 575 | 72 | 26 | 9 | 4 | — | 686 | 15.1 | 12.0 | 8.7 | 4.5 | 4.0 | — | 13.7 |
| S. 48 | Wales | 37 | 6 | 3 | 4 | — | — | 50 | 596 | 88 | 30 | 44 | — | — | 758 | 16.1 | 14.7 | 10.0 | 11.0 | — | — | 15.2 |
| Check | — | 17 | 8 | 10 | 11 | 4 | — | 50 | 317 | 63 | 81 | 47 | 9 | — | 517 | 18.6 | 7.9 | 8.1 | 4.3 | 2.2 | — | 10.3 |
| Gloria | Sweden | 29 | 5 | 4 | 7 | 5 | — | 50 | 557 | 91 | 32 | 47 | 12 | — | 739 | 19.2 | 18.2 | 8.0 | 6.7 | 2.4 | — | 14.8 |
| Bottnia | Sweden | 4 | 3 | 6 | 12 | 22 | 3 | 50 | 107 | 47 | 49 | 64 | 65 | 6 | 338 | 26.7 | 15.7 | 8.1 | 5.3 | 2.9 | 2.0 | 6.8 |
| Check | — | 15 | 11 | 3 | 8 | 12 | 1 | 50 | 285 | 250 | 31 | 42 | 34 | 3 | 645 | 19 0 | 22.7 | 10.3 | 5.2 | 2.8 | 3.0 | 12.9 |

SINGLE-PLANT STRAINS FROM BRITISH ISLES AND NORTHERN EUROPE

| Designation of strain | Origin | Frequencies within grades of rust injury. Sept., 1932 | | | | | | | Total green yields in ounces within grades of rust injury. 1933 | | | | | | | Average green yields per plant in ounces within grades of rust injury. 1933 | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 | 4 | 5 | Total | 0 | 1 | 2 | 3 | 4 | 5 | Total | 0 | 1 | 2 | 3 | 4 | 5 | Average |
| 1002 | | 22 | 0 | 0 | 1 | 2 | — | 25 | 629 | — | — | 10 | 8 | — | 647 | 28.6 | — | — | 10.0 | 4.0 | — | 25.9 |
| Check | | 12 | 3 | 2 | 4 | 4 | — | 25 | 227 | 47 | 24 | 15 | 5 | — | 318 | 18.9 | 15.7 | 12.0 | 3.7 | 1.2 | — | 12.7 |
| 1015 | | 1 | 1 | 2 | 4 | 15 | 2 | 25 | 24 | 18 | 7 | 7 | 16 | 1 | 73 | 24.0 | 18.0 | 3.5 | 1.7 | 1.0 | 0.5 | 2.9 |
| Check | | 9 | 7 | 3 | 4 | 2 | — | 25 | 187 | 78 | 14 | 32 | 6 | — | 317 | 20.8 | 11.1 | 4.7 | 8.0 | 3.0 | — | 12.7 |
| 1022 | | 9 | 8 | 6 | 2 | — | — | 25 | 158 | 129 | 39 | 12 | — | — | 338 | 17.5 | 16.1 | 6.5 | 6.0 | — | — | 13.5 |
| 1028 | | 11 | 5 | 4 | 1 | 4 | — | 25 | 246 | 58 | 39 | 14 | 24 | — | 381 | 22.4 | 11.6 | 9.7 | 14 0 | 6.0 | — | 15.2 |
| Check | | 6 | 6 | 4 | 6 | 3 | — | 25 | 112 | 49 | 33 | 28 | 5 | — | 227 | 18.7 | 8.1 | 8.2 | 4.7 | 1.7 | — | 9.1 |
| 1035 | | 19 | 4 | 0 | 2 | — | — | 25 | 201 | 36 | — | 7 | — | — | 244 | 10.6 | 9.0 | — | 3.5 | — | — | 9.8 |
| 1036 | | — | 3 | 3 | 10 | 9 | — | 25 | — | 26 | 3 | 7 | 5 | — | 41 | — | 8.7 | 1.0 | 0.7 | 0.5 | — | 1.6 |
| 1037 | | 24 | 0 | 0 | 0 | 1 | — | 25 | 427 | — | — | — | 7 | — | 434 | 17.8 | — | — | — | 7.0 | — | 17.4 |
| 1038 | | 16 | 4 | 0 | 2 | 3 | — | 25 | 255 | 55 | — | 22 | 11 | — | 343 | 15.9 | 13.7 | — | 11.0 | 3.7 | — | 13.7 |
| Check | | 11 | 2 | 1 | 8 | 3 | — | 25 | 153 | 10 | 12 | 20 | 8 | — | 203 | 13.9 | 5.0 | 12.0 | 2.5 | 2.7 | — | 8.1 |
| 1041 | | 15 | 6 | 0 | 3 | 1 | — | 25 | 205 | 67 | — | 5 | 6 | — | 283 | 13.7 | 11.1 | — | 1.7 | 6.0 | — | 11.3 |
| Check | | 9 | 5 | 5 | 3 | 3 | — | 25 | 131 | 45 | 42 | 15 | 7 | — | 240 | 14 5 | 9.0 | 8.4 | 5.0 | 2.3 | — | 9.6 |
| 1053 | | 20 | 2 | 2 | — | — | — | 24 | 370 | 27 | 30 | — | — | — | 427 | 18 5 | 13.5 | 15.0 | — | — | — | 17.8 |
| Check | | 12 | 5 | 5 | 1 | 2 | — | 25 | 146 | 55 | 45 | 2 | 8 | — | 256 | 12.2 | 11.0 | 9.0 | 2.0 | 4.0 | — | 10.2 |
| All strains | | 551 | 297 | 86 | 92 | 110 | 13 | 1149 | 10161 | 4556 | 634 | 434 | 246 | 12 | 16043 | — | — | — | — | — | — | — |
| Average weight of plants | | — | — | — | — | — | — | — | 18 4 | 15 3 | 7 4 | 4.7 | 2.2 | 0.9 | — | 18.7 | 14.3 | 8.2 | 5.9 | 3.1 | 1.1 | 13.8 |
| All checks | | 220 | 168 | 77 | 81 | 51 | 3 | 600 | 3897 | 2338 | 617 | 373 | 127 | 5 | 7357 | — | — | — | — | — | — | — |
| Average weight of plants | | — | — | — | — | — | — | — | 17.7 | 13.9 | 8 0 | 4.6 | 2.5 | 1.7 | — | 17.6 | 12.5 | 8.3 | 4.7 | 2.7 | 1.7 | 11.9 |

## INFLUENCE OF RUST INJURY ON SPRING VIGOUR

The influence of rust injury incurred during the late summer of 1932 was clearly evident among plants in the nursery in the following spring. Differences in the vigour of strains, and of individuals within strains, appeared quite striking and suggested a close correlation with the rust injury of the previous year. In order to test this correlation, individual plants throughout the entire test were graded according to the following scale:

*Grades of Spring Vigour, May, 1933*

0 = plant dead;
1 = plant showing only faint indications of life;
2, 3, 4 and 5 = plants showing increasing degrees of vigour.

The frequencies within these grades for the plants of 29 strains, grown together in one section of the nursery, are presented in Table 1, along with the corresponding frequencies within rust grades obtained in September of the previous year. Similar data have been presented for the nearest check, which follows each strain or group of strains throughout the table.

A survey of the frequencies presented in this table will reveal some outstanding differences between strains in regard both to rust injury and to spring vigour. High frequencies in the lower grades of rust injury are associated with low frequencies in the lower grades of spring vigour, and vice versa. Moreover, this relationship is apparent whether strains are considered singly or combined.

## INFLUENCE OF RUST INJURY ON YIELD

During the early summer of 1933, differences in vigour, far from becoming obliterated by the season's growth, became much more intensified (Figure 1). On this account it seemed worth while to obtain green yields from individual plants immediately following bloom in order to arrive at a more exact appreciation of the influence of the different grades of rust injury than a grading for vigour allowed.

The frequencies within various grades of rust injury, along with corresponding total green yields, as well as the corresponding average yield per plant within these grades for 28 representative strains, are presented in Table 2. Similar data for the nearest check follow each strain or group of strains. From these results, the average green yields per plant within each grade of rust injury have been calculated, both for the 28 strains and for the common "check" strain. These averages are expressed graphically in Figures 2 and 3. For increasing grades of rust injury, viz., 0, 1, 2, 3, 4, and 5, the corresponding average green yields of plants for 28 strains were 18.4, 15.3, 7.4, 4.7, 2.2 and 0.9 ounces respectively and for the common "check" strain 17.7, 13.9, 8.0, 4.6, 2.5 and 1.7 ounces respectively. The average green yields of plants within the various grades of rust injury in the case of the common "check" strain did not differ greatly from those obtained when 28 representative strains were averaged.

A statistical measure of the significance of rust injury as a factor influencing the yield of timothy may be obtained from a comparison of the variance (*2*) between and within grades of rust injury for the 28 strains as shown in Table 3.

FIGURE 1. Influence of rust injury on yield of timothy; differential injury between and within three strains.

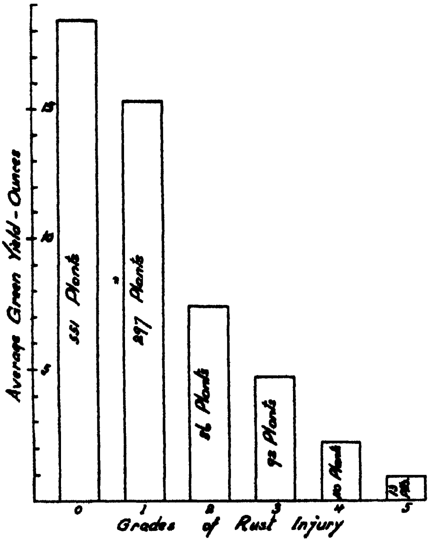

FIGURE 2. Average green yields per plant in ounces within grades of rust injury for 28 strains — 1149 plants.

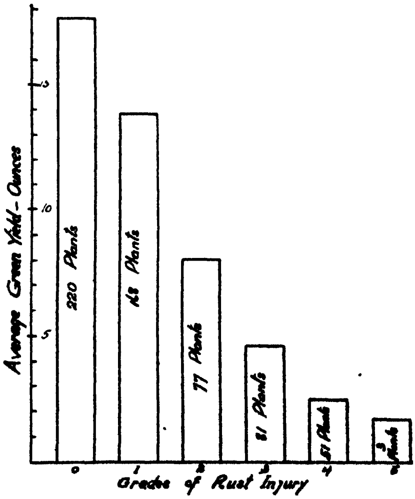

FIGURE 3. Average green yields per plant in ounces within grades of rust injury for "Check" strain—600 plants.

TABLE 3.—VARIANCE OF YIELDS BETWEEN AND WITHIN RUST GRADES

| — | Sum of squares | D.F. | Mean square | ½ Log$_e$ (M.S.) | *z* value | *z* value for 1% point |
|---|---|---|---|---|---|---|
| Strains: Total (28) | | | | | | |
| Plants: 1149 | | | | | | |
| Mean yield: 13 8 ozs. | | | | | | |
| Between grades: | 40,536.34 | 5 | 8,107.26 | 3.349 | 2.8702 | 0.552 |
| Within grades: | 29,797.05 | 1143 | 26.07 | 0.479 | | |

A comparison of the *z* value with the corresponding 1% point in the above data reveals a significant difference between the yields obtained in the six grades of rust injury.

Significant differences are also obtained when high, medium, and low-yielding strains are selected and given the same statistical treatment. (Table 4).

TABLE 4.—VARIANCE OF YIELDS BETWEEN AND WITHIN RUST GRADES

| — | Sum of squares | D.F. | Mean square | ½ Log$_e$ (M.S.) | *z* value | *z value* for 1% point |
|---|---|---|---|---|---|---|
| *High:* | | | | | | |
| Strain: M.C. No. 710 | | | | | | |
| Plants: 50 | | | | | | |
| Mean yield: 19.1 ozs. | | | | | | |
| Between grades: | 382.77 | 4 | 95.69 | 1.129 | 0.979 | 0.647 |
| Within grades: | 607.26 | 45 | 13.49 | 0.150 | | |
| *Medium:* | | | | | | |
| Strain: Cornell 4059 | | | | | | |
| Plants: 49 | | | | | | |
| Mean yield: 7.7 ozs. | | | | | | |
| Between grades: | 1031.12 | 4 | 257 78 | 1.625 | 1.346 | 0 647 |
| Within grades: | 767.94 | 44 | 17 45 | 0.278 | | |
| *Low:* | | | | | | |
| Strain: Lappi | | | | | | |
| Plants: 43 | | | | | | |
| Mean yield: 4 5 ozs. | | | | | | |
| Between grades: | 1129.66 | 4 | 282 41 | 1.670 | 1.631 | 0.695 |
| Within grades: | 411.06 | 38 | 10.82 | 0.039 | | |

The *z* value in each case exceeds the 1% point by a considerable margin.

A study of the average green yields per plant for different strains, as presented in the last column of Table 2, reveals some rather outstanding differences in yield per plant. On the other hand, when the average yields of plants classified according to rust injury for these same strains are compared no such differences between strains are apparent. This would suggest that, under the conditions of this study, rust injury was a very important factor influencing the yielding ability of these strains.

## DISCUSSION

There are a number of reasons why one might expect to find in the literature a diversity of opinion regarding the economic importance of timothy rust. Seasonal or local conditions, or both, may either favour or retard the development of the disease. The rust attack may arrive too late in the season to influence the hay crop of that year, but may seriously affect the seed crop as in Wales (*5*), or the influence of the rust injury may be carried over and affect the hay crop of the following year and may even curtail the longevity of the crop, as Webber (*6*) has pointed out. Consideration must also be given to the differential reaction of timothy strains to rust attack. Plant breeders such as Webber (*6*), Witte (*7*), Clarke (*1*) and others have demonstrated the possibility of isolating disease-resistant strains. Moreover, in regions where timothy rust has frequently been destructive, it is conceivable that natural selection may have eliminated a large proportion of the more susceptible plants from the regional population, with a consequent improvement in disease resistance. There is also the possibility that different species of fungi or different physiologic forms may be responsible for timothy rust in different places and therefore cause differences of opinion as to the importance of the disease.

One of the most striking features of strain reaction in this test was the high susceptibility of strains from Scandinavian Europe. The improved strains—Gloria, from the Svalof station, and Φtofte from the Φtoftegaard station—were, however, outstanding in their resistance to the disease, when compared with ten other Scandinavian strains included in the test. Similar observations have been made by Stapledon (*5*) in respect to the rust of different species of grasses.

Generally speaking, the large majority of improved strains included in this test showed marked resistance and gave a clear-cut demonstration of the result of careful selection for rust-resistance at the various stations where they were produced.

Although strains differed greatly in their reaction to the disease, the reaction of individual plants within strains also varied greatly. No strains were found to be 100% free from the disease. Even in those strains with lowest injury, individuals were found showing, in some cases slight, and in others definite, indications of rust injury. Likewise, in the most susceptible strains, exceptional plants were found, which were quite vigorous in appearance and either free from, or showing slight indications of, rust injury. These latter plants were, in many cases, surrounded by individuals showing abundant infection and severe injury. In a large proportion of the strains, there was a regular gradation of rust injury presented by individuals within the strain, varying from plants showing no trace of the disease to others almost dead as a result of it. To account for such plant-to-plant variation within strains, the possibility of irregular infection could not be ruled out, but it seemed more likely that the variation was due to a differential resistance of individuals within the strain to rust attack.

In devising a scale for the gradation of plants according to rust injury, it appeared necessary to consider not only intensity of infection, as indicated by the development of pustules upon the leaves, but also the influence of the parasite upon the vigour of its host. One might have expected that, under apparently increasing amounts of infection, plants would have shown increasing degrees of injury, but this was not always the case. Certain plants seemed to withstand a given amount of infection, as judged by pustule development, with much less injury than others, due perhaps, to genotypic differences between the individual plants.

While such decreases in vigour and yield due to rust injury, obtained from a study of individual plants, are not directly applicable to field conditions, where plants grow matted together in a sod, they are nevertheless indicative of the serious nature of the disease. Furthermore, the differential injury of strains, and of individuals within strains, by this disease would appear an important cause of variability in breeding material and should therefore be given consideration, whenever comparisons are made either between or within strains.

It should not be assumed that such injury to timothy as resulted from the rust epidemic of 1932 would prevail in every season. The severity of the rust attack in this particular year was of an exceptional nature, as has been pointed out above. The results presented are therefore not indicative of average conditions; otherwise, the differences between yields of plants classified according to rust grade might have been considerably less significant. For the establishment of differences in rust-resistance of strains, it would seem necessary that environmental conditions should strongly favour the development of the disease. In nature, such environmental conditions are largely beyond the control of the plant breeder, and the only course for him to follow, under such circumstances, is to await an epidemic of the disease. On the other hand, controlled infection of plants in the greenhouse would seem to offer some promise in the study of strain reaction.

## SUMMARY

Results are presented from a study of the influence of rust injury on the vigour and yield of timothy in the following year.

The study was based upon individual plants within 116 local and foreign strains. These plants were graded according to rust injury during an epidemic of timothy rust which commenced in the late summer of 1932. The same plants were graded according to spring vigour in May of the following year. Individual plant yields were obtained for a number of representative strains by taking green yields of plants immediately following bloom.

A comparison of the yield of these individual plants within different grades of rust injury in 28 strains indicated the importance of the disease as a cause of differential vigour and yield within and between strains.

## ACKNOWLEDGMENT

Acknowledgment is made of the kindly assistance and advice of members of the staff in Agronomy and Plant Pathology in connection with this study.

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## L'EFFET DE LA ROUILLE SUR LA VIGUEUR ET LE RENDEMENT DU MIL. J. N. Bird, Collège Macdonald, P.Q.

Sous ce titre, sont présentés les résultats d'une étude de l'effet de la rouille sur la vigueur et le rendement de la fléole des près (mil) l'année suivante (1933). L'étude était basée sur des plantes séparées, appartenant à 116 espèces locales et étrangères. Ces plantes ont été classées d'après les dégâts causés par la rouille au cours d'une épidémie de rouille de la fléole qui a commencé à sévir vers la fin de l'été de 1932, et ont été reclassées une deuxième fois d'après la vigueur qu'elles avaient en mai de l'année suivante. On s'est procuré les rendements individuels par plante d'un certain nombre d'espèces représentatives en prenant les rendements en vert des plantes immédiatement après la floraison. Une comparaison du rendement de ces différentes plantes pour différents degrés de dégâts causés par la rouille dans 28 espèces a fait ressortir l'importance de la maladie comme cause des différences de vigueur et de rendement dans les espèces et entre les expèces.

# THE INHIBITION OF THE GROWTH OF FUNGI BY CHEMICALS[1]

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[Received for publication March 29, 1934]

Although there exists considerable information on the concentrations of various chemicals that are lethal to fungi comparatively little information is available upon the concentrations that inhibit the growth of fungi, and these two critical concentrations may not be related. At concentrations lethal to fungi many chemicals are quite toxic to the host plant, while at a concentration that inhibits fungal growth the chemical may possess little if any toxicity toward the host plant. These investigations have been conducted in the hope of discovering solutions that would be absorbed by seed in sufficient quantities to exert an immunizing effect during the seedling stage of their growth. There are many plants that appear to be parasitized by fungi during the seedling stage only. Dessy (*1*) determined the inhibitory effect of 51 colouring agents and 24 metallic salts on the growth of *Penicillium* spp. He found active inhibition of growth by brilliant green, methyl violet, malachite green, alizarin blue, among the dyes and by mercury cyanide, mercuric chloride, cadmium nitrate and aluminium sulphate among the salts. In a later publication (*2*) Dessy investigated the effect of these compounds on *Mucor* spp. and found that the inhibitory effect was much less marked than for the *Penicillium* spp.

There have been no extensive investigations of the inhibitory effect of chemicals on the growth of *Fusarium* spp. Reynolds (*4*) reports that a minimum concentration of 0.3 molar of potassium cyanide prevented the growth of *F. lini bolley*. Houben and Wollenweber (*3*) found that concentrations of 0.005% to 0.01% of hexylresorcinol inhibited the growth of *F. aurantiacum* while *F. lini* required concentrations of 0.01% to 0.02%. Wollenweber also reports (*5*) that a concentration of 0.03% chinosol inhibits the growth of *F. lini*.

## Determination of the Inhibition Concentrations

*Experimental.*—The nutrient medium used for this work was of the following composition:—

| | | | |
|---|---|---|---|
| $Na_2HPO_4$ | 0.4 gm. | Sucrose | 40.0 gm. |
| $KNO_3$ | 0.4 gm. | Water | 1000.0 cc. |
| $MgSO_4$ | 0.4 gm. | | |

This medium was pipetted in 10 cc. amounts into test tubes and sterilized for 15 minutes at 15 lbs. pressure. Solutions of the chemical under investigation were made up at twice the concentration desired, pipetted in 10 cc. amounts into test tubes, and sterilized.

The following procedure was adopted: one test tube each of the medium and the chemical solution were poured into a petri dish and the mixture inoculated with a piece of fresh living mycelium of the fungus under investigation. The petri dishes were then incubated at 25° C. and after

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[1] Contribution No. 397 from the Division of Botany, Experimental Farms Branch, Department of Agriculture, Ottawa, Ont.

7 days those concentrations of the chemical which completely prevented growth of the fungus were noted.

The inhibition concentrations towards four *Fusarium* spp. were investigated, namely *F. culmorum* (W. G. Sm.) Sacc., *F. moniliforme* Sheldon, *F. solani* (Mart.) App. et Wr., and *F. orthoceras* App. et Wr., representing the sections Discolor, Moniliforme, Martiella, and Elegans respectively. Table 1 shows the concentrations of chemicals which inhibited the growth of these *Fusarium* spp. under these experimental conditions, while Table 2 shows the chemicals which do not inhibit growth up to concentrations of 0.1 M. The accuracy of the inhibition constants is within 10% of the recorded values.

TABLE 1.—THE INHIBITION CONSTANTS OF CHEMICALS TOWARD *Fusarium* SPP. EXPRESSED AS MOLAR SOLUTIONS AND PER CENT CONCENTRATIONS

| Chemical | Fusarium culmorum | Fusarium moniliforme | Fusarium solani | Fusarium orthoceras. |
|---|---|---|---|---|
| Potassium dichromate | 0.0003 M | 0.0007 M | 0.0007 M | 0.0003 M |
| Phenol | 0.005 M | 0.001 M | 0.0007 M | 0.0007 M |
| Mercuric chloride | 0.001 M | 0.0006 M | 0.0008 M | 0.0005 M |
| Cresol | 0.001 M | 0.001 M | 0.001 M | 0.001 M |
| Cheshunt compound ($CuSO_4$ 2 parts $(NH_4)_2CO_3$ 9 parts, molarity as copper sulphate | 0.001 M | 0.001 M | 0.001 M | 0.001 M |
| Mercurous sulphate | Saturated solution (approx. 0.001 M) | | | |
| Sodium bisulphite | 0.007 M | 0.007 M | 0.007 M | 0.007 M |
| Guaicol | 0.007 M | 0.007 M | 0.008 M | 0.007 M |
| Molybdic acid | Saturated solution (approx. 0.01 M) | | | |
| Lead chloride | Saturated solution (approx. 0.01 M) | | | |
| Zinc sulphate | 0.01 M | 0.02 M | 0.06 M | 0.01 M |
| Resorcinol | 0.1 M | 0.1 M | 0.1 M | 0.1 M |
| Malachite Green | 0.001 % | 0.0006 % | 0.001 % | 0.0006 % |
| Chinosol | 0.006 % | 0.01 % | 0.006 % | 0.006 % |
| Methylene Blue | 0.05 % | 0.05 % | 0.05 % | 0.05 % |
| Magenta | 0.05 % | 0.05 % | 0.05 % | 0.1 % |
| Indine Blue | 0.1 % | 0.1 % | 0.1 % | 0.1 % |

TABLE 2.—CHEMICALS WHICH DO NOT INHIBIT THE GROWTH OF *Fusarium* SPP. UP TO CONCENTRATIONS OF 0.1 M (APPROXIMATELY 0.1 %)

| Inorganic chemicals | Organic chemicals | Inorganic chemicals | Organic chemicals |
|---|---|---|---|
| Potassium iodate | Picric acid | Potassium thiocyanate | Aniline Blue |
| bromate | Benzoic acid | ferricyanide | Fluorescin |
| chlorate | Amyl acetate | ferrocyanide | Nigrosine |
| iodide | Auramine | permanganate[1] | |
| bromide | Rhodamine | Ferric chloride[2] | |
| chloride | Fuchsin | Sodium tartrate | |

[1] The non-inhibiting effect of potassium permanganate was due to its reaction with the media resulting in its being reduced to manganese dioxide.

[2] The ferric chloride was almost completely converted to the oxide and as such did not show any inhibiting effect.

TABLE 3.—THE INHIBITION CONSTANTS OF CHEMICALS TOWARDS *Fusarium*, *Rhizoctonia* AND *Pythium*, EXPRESSED AS MOLAR SOLUTIONS AND PERCENT CONCENTRATIONS.

| Chemical | *F. culmorum* | | *Pythium* | | *Rhizoctonia* | |
|---|---|---|---|---|---|---|
| | Growth | No growth | Growth | No growth | Growth | No growth |
| Copper sulphate | 0.0001 M | 0.001 M | 0.0001 M | 0.001 M | 0.0001 M | 0.001 M |
| Copper nitrate | 0.001 M | 0.001 M | 0.0001 M | 0.001 M | 0.0001 M | 0.0001 M |
| Copper acetate | 0.0001 M | 0.001 M | 0.0001 M | 0.001 M | 0.0001 M | 0.001 M |
| Mercuric chloride | 0.0001 M | 0.001 M | 0.0001 M | 0.001 M | 0.0001 M | 0.001 M |
| Mercuric cyanide | 0.0001 M | 0.001 M | 0.0001 M | 0.001 M | 0.0001 M | 0.001 M |
| Silver nitrate | 0.0001 M | 0.001 M | 0.0001 M | 0.001 M | 0.0001 M | 0.001 M |
| Potassium dichromate | 0.0001 M | 0.001 M | 0.0001 M | 0.001 M | 0.0001 M | 0.001 M |
| Phenol | 0.0001 M | 0.001 M | 0.0001 M | 0.001 M | 0.0001 M | 0.001 M |
| Guaicol | 0.001 M | 0.01 M | 0.001 M | 0.01 M | 0.001 M | 0.01 M |
| Cresol | 0 001 M | 0.01 M | 0.001 M | 0.01 M | 0.001 M | 0.01 M |
| Potassium cyanide | 0.001 M | 0.01 M | 0 001 M | 0.01 M | 0.001 M | 0.01 M |
| Tannic acid | 0.001 M | 0.01 M | 0 001 M | 0.01 M | 0.001 M | 0.01 M |
| Barium chloride | 0.01 M | 0.1 M | 0 001 M | 0.01 M | 0.01 M | 0.1 M |
| Malachite green | 0.0001 % | 0.001 % | 0.0001 % | 0.001 % | 0.0001 % | 0.001 % |

TABLE 4.—THE EFFECT OF CHEMICALS ON THE GROWTH OF WHEAT SEEDLINGS AS SHOWN BY THE HEIGHT OF THE SEEDLINGS

| Chemical | Concentration | Height in cm. | Chemical | Concentration | Height in cm. |
|---|---|---|---|---|---|
| Check | | 16.0 | Chinosol | 0.1 % | 12.0 |
| | | | | 0.01 % | 14.0 |
| Copper acetate | 0.01 M | 4.0 | | | |
| | 0.001 M | 14.0 | Mercurous sulphate | Sat. soln. | 15.0 |
| Copper sulphate | 0.01 M | 4.5 | Lead chloride | Sat. soln. | 14.0 |
| | 0.001 M | 13.5 | | | |
| | 0.0001 M | 16.5 | Zinc sulphate | 0.1 M | 7.5 |
| Cheshunt compound | 0.01 M | 3.5 | Barium chloride | 0.1 M | 5.5 |
| | 0.001 M | 13.0 | | | |
| | | | Guaicol | 0.01 M | 8.0 |
| Copper nitrate | 0.01 M | 4.5 | | | |
| | 0.001 M | 12.0 | Molybdic acid | Sat. soln. | 8.5 |
| | 0.0001 M | 15.5 | | | |
| | | | Silver nitrate | 0.1 M | 4.5 |
| | | | | 0.01 M | 8.0 |
| Potassium dichromate | 0.01 M | 4.5 | | 0.001 M | 7.5 |
| | 0.001 M | 10.5 | | | |
| | | | Mercuric cyanide | 0.1 M | Killed |
| Potassium cyanide | 0.1 M | 3.5 | | 0.01 M | Killed |
| | 0.01 M | 13.4 | | 0.001 M | 8.5 |
| Cresol | 0.1 M | 10.0 | Mercuric chloride | 0.1 M | Killed |
| | | | | 0.01 M | 5.5 |
| Phenol | 0.1 M | 7.0 | | 0.001 M | 7.5 |
| | 0.01 M | 14.0 | | | |
| | | | Resorcinol | 0.1 M | Killed |
| Malachite green | 0.1 % | 7.5 | | | |
| | 0.01 % | 10.5 | | | |
| | 0.001 % | 11.0 | | | |

TABLE 5.—THE RELATIVE CONCENTRATIONS OF CHEMICALS INHIBITING THE GROWTH OF FUNGI AND WHEAT

| Chemical | Minimum concentration inhibiting fungi | Maximum concentration not inhibiting wheat | Ratio |
|---|---|---|---|
| Phenol | 0.001 M | 0.01 M | 10 |
| Cresol | 0.01 M | 0.1 M | 10 |
| Chinosol | 0.01 % | 0.1 % | 10 |
| Malachite green | 0.001 % | 0.1 % | 10 |
| Copper sulphate | 0 001 M | 0 001 M | 1 |
| Copper nitrate | 0.001 M | 0.001 M | 1 |
| Copper acetate | 0.001 M | 0.001 M | 1 |
| Cheshunt compound | 0.001 M | 0.001 M | 1 |
| Potassium dichromate | 0.001 M | 0.001 M | 1 |
| Potassium cyanide | 0 01 M | 0.01 M | 1 |
| Mercurous sulphate | Sat. soln. | Sat. soln. does not inhibit | 1 |
| Lead chloride | Sat. soln. | Sat. soln. does not inhibit | 1 |
| Molybdic acid | Sat. soln. | Sat. soln. inhibits | Below 1 |
| Zinc sulphate | 0.1 M | Below 0.1 M | Below 1 |
| Barium chloride | 0.1 M | Below 0.1 M | Below 1 |
| Silver nitrate | 0.001 M | Below 0.001 M | Below 1 |
| Mercuric chloride | 0.001 M | Below 0.001 M | Below 1 |
| Mercuric cyanide | 0.001 M | Below 0.001 M | Below 1 |
| Resorcinol | 0.1 M | Below 0.1 M | Below 1 |
| Guaicol | 0.01 M | Below 0.01 M | Below 1 |

It will be seen from Table 1 that the inhibition concentrations were practically the same for the four species of *Fusarium*. Hence, in later investigations only one species, *F. culmorum*, was used and this species of *Fusarium* was compared with species of other genera namely, *Rhizoctonia solani* Kühn and *Pythium ultimum* Trow. Those chemicals that materially inhibited the growth of the *Fusarium* spp. and other chemicals were studied in the later investigation. Dilutions of one to ten only were made, hence the inhibition concentrations may be anywhere between the two values recorded in Table 3.

## THE INHIBITION OF GROWTH OF WHEAT SEEDLINGS

In order to determine the possible utility of the more effective chemicals as a soil treatment against infection it was necessary to find the effect of the chemicals on the growth of seedlings. Wheat was chosen as a test crop since it is a fairly rapid grower and easily handled.

Wheat was germinated by placing it in the incubator between wet blotting paper for 36 hours. Lots of twenty well germinated seeds were then counted and placed on wire gauze over an open half petri dish. Hoagland's plant nutrient solution was poured into the dish and the seedlings allowed to grow for 7 days at which time they were about 4 cm. high. At this time fresh Hoagland's solution containing the chemicals under investigation was added and the plants were grown for another seven days after which the growth was determined by measuring the length of the plant. The data are presented in Table 4.

## DISCUSSION

The important factor in work of this type is not so much to obtain a chemical which at low concentrations is inhibitory to fungal growth as one that while inhibitory to the fungous is non-inhibitory to plant growth at concentrations considerably higher than it is inhibitory to fungal growth. That is, the ratio of "dosis tolerata" to "dosis toxica" should be as high as possible. Reference to Table 4, shows that with the exception of copper sulphate at a concentration of 0.001 molar and copper nitrate at the same concentration, none of the chemicals used in this investigation was without some effect on the plants. The first eleven chemicals in Table 4, however, while retarding growth to some extent did not cause serious injury at concentrations above that required to inhibit the growth of the fungus.

Table 5, shows the minimum concentration of the various chemicals which inhibited fungal growth and the maximum concentrations which allowed the wheat to grow to a height of at least 10 cm. The final column shows the ratio of "dosis tolerata" to "dosis toxica." The ratio was greater than one only in four cases, namely, phenol, cresol, chinosol, and malachite green. In the cases of copper sulphate, acetate and nitrate, Cheshunt compound, potassium cyanide, mercurous sulphate, lead chloride and potassium dichromate, the ratios were one, while the other chemicals gave ratios below one indicating that the concentration required to inhibit the fungus is greater than the maximum concentration tolerated by the wheat.

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## RESUME

### L'EFFET DE CERTAINS INGRÉDIENTS CHIMIQUES SUR LA CROISSANCE DES CRYPTOGAMES.

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L'effet d'un certain nombre de concentrations d'ingrédients chimiques sur des espèces de *Fusarium*, de *Pythium* et de *Rhizoctonie* et l'effet de ces concentrations et d'autres sur la croissance des plantules de blé ont été déterminés. La proportion entre les concentrations maxima tolérées par les plantules de blé et les concentrations minima qui arrêtent la croissance des champignons, était de dix pour le phénol, le crésol, le chinosol et le vert malachite, et d'un pour le sulfate de cuivre, le nitrate de cuivre, l'acétate de cuivre, le composé Cheshunt, le dichromate de potassium, le cyanure de potassium et le chlorure de plomb. Tous les autres ingrédients chimiques à l'essai ont donné une proportion inférieure à un. Ceci porte à croire que seuls les ingrédients chimiques qui paraissent sur cette liste peuvent être utiles dans la lutte contre les maladies des plantes.

# THE EFFICIENCY OF USE OF FARM POWER[1]

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[Received for publication February 22, 1934]

The cost of farming operations involving the use of power is materially influenced by the efficiency with which the power is used. In other words, the ratio of power actually used to the potentialities of the power unit is an important cost factor. In ordinary field operations the power used must have some margin over the usual draft requirement of the implement being operated, but the amount of surplus cannot be easily determined. With horses, lack of a surplus of power is not immediately evident, and there are good reasons for supposing that many horses are overworked for considerable periods. With tractors, lack of a surplus results almost immediately in stalling of the outfit; hence tractors are almost certain to be operating loads below their maximum capacity.

To determine the extent of such overloading or underloading, a series of drawbar tests (45 in all) were made in the summer and fall of 1931. The season was hot and unusually dry, thus resulting in higher draft for plows and lower draft for such implements as combines. To obtain the necessary data, it was decided to make a series of draft tests under actual farm conditions. An hydraulic dynamometer, steel tape, and stop watch were loaded in an automobile, and by driving out into the surrounding district farmers were found at work. Each farmer whose outfit was tested was asked to continue his operations without making any adjustments, and as the routine of the test had been well worked out previously, the loss of time to the farmer was less than five minutes per test and in many cases did not exceed two minutes. This was an important factor in securing the voluntary co-operation of the farmer. In addition the farmer was promised the results of the test by mail, and in this way his correct name and address were secured. This plan succeeded excellently, only one refusal being received.

The tests made by this method naturally cover a broad group of conditions. The tillage implements studied were all in the Red River valley within a radius of 30 miles of Winnipeg. The combines tested were all within a 20 mile radius of Portage la Prairie.

*Type of outfit studied.*—The tests made included 10 horse outfits and 35 tractor outfits. Plows, discs and cultivators were the implements being hauled by horses, while the tractor loads comprised plows, disc tillers, cultivators and 12 combines. The size of outfits varied from 3 horse to 8 horse, and the tractors varied in the maximum Draw Bar Horse Power from 8.25 to 33.2 h.p.

*Results of the tests.*—The graph (Plate I) gives the results of the various drawbar tests made. In this graph the heavy vertical bars represent the average h.p. developed by each outfit. Reading from the left, the first

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[1] The Canadian Pioneer Problems Committee commissioned the authors to investigate the efficiency with which Manitoba farmers were utilizing the various types of power units. The discussion which follows is summarized from the report sent to the Committee and is given with their authorization.

[2] Specialist in Agricultural Engineering and Professor of Agricultural Engineering respectively.

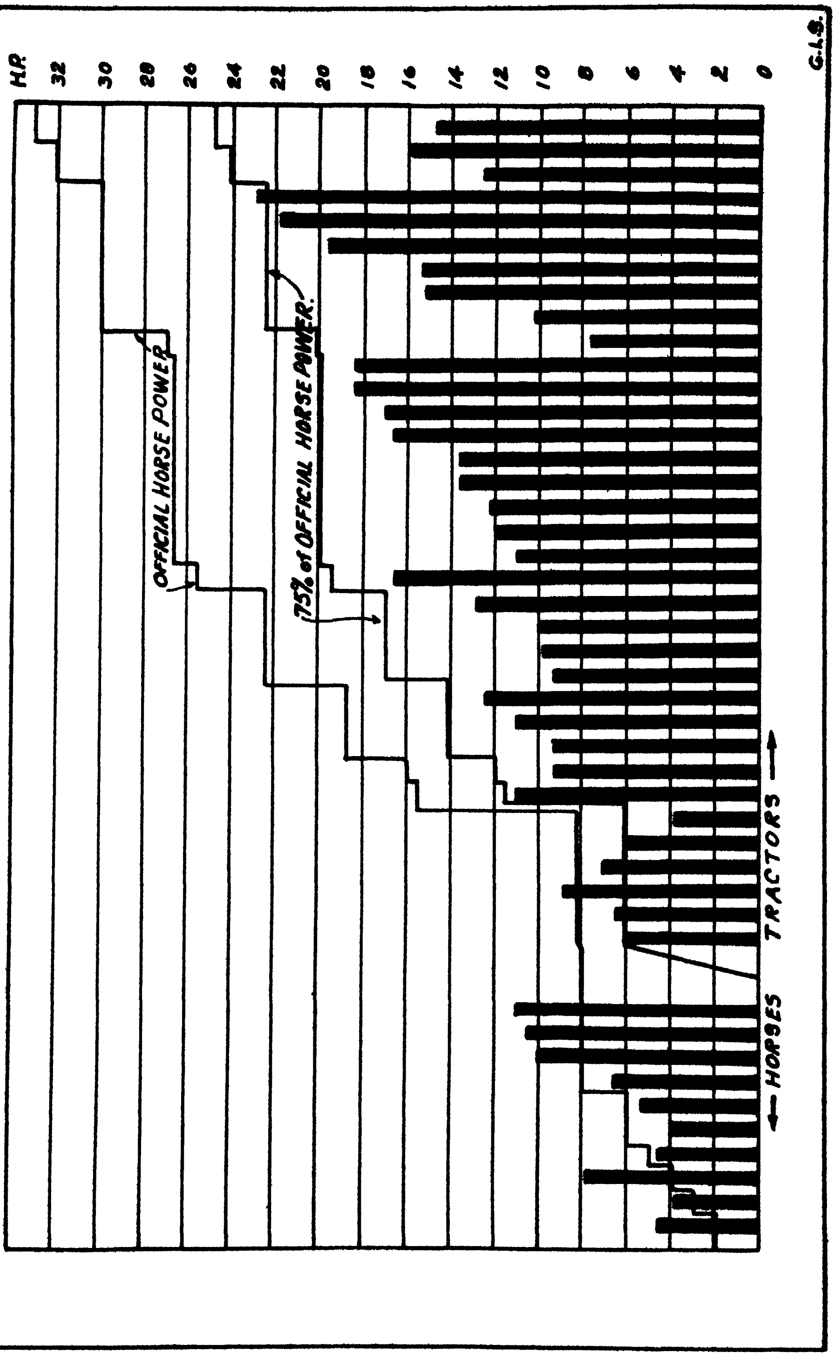

PLATE I.— HORSE POWER DEVELOPED COMPARED WITH OFFICIAL HORSE POWER.

ten tests were horse outfits and the remainder were tractors. Above the vertical bars is drawn a series of horizontal reference lines joined for convenience by vertical lines. These horizontal lines marked "Official Horse Power" denote, in the case of horse outfits, the number of horses; in the case of tractors, the position of the line denotes the maximum drawbar horse power of the tractor according to the Nebraska tractor tests. In the case of the tractor tests a second series of horizontal lines marked "75% of Official Horse Power" is also shown on the graph for reference purposes, it being the opinion of the authors that this proportion of the maximum power is all that can be safely utilized under field conditions. An examination of the graph shows, therefore, that in the case of horse outfits six out of the ten were overloaded—some, as for example No. 3, to a marked degree—and that the surplus power in the other horse tests is not excessive. For tractors, it will be noted that only six of the thirty-five reach, or pass, the 75% line, and that the margin of surplus in the average case is large. The tractor tests are arranged in groups according to their power, the smallest being on the left and largest on the right. In general it will be noted that the smaller tractors are more nearly fully loaded than are the larger ones. From the results of these tests the following conclusions are drawn.

## CONCLUSIONS

1. The limited number of tests made and their restriction to one general soil type in so far as tillage implements are concerned does not justify any sweeping conclusions or broad generalizations. The following tentative conclusions seem fairly justified by the present work.

(a) Horse outfits are more likely to be loaded to capacity than are tractor outfits.

(b) Higher overloads will be found with horse outfits than with tractor outfits.

(c) The smaller tractors are more nearly loaded to capacity than the larger tractors.

(d) As the size of the tractor increases, the probability of it being loaded to capacity decreases. The three tractors to the extreme right of the graph (Plate I) are the largest in the group and none of these were loaded to 50% capacity.

(e) The speed of horse drawn outfits which averages 2.68 miles per hour is somewhat higher than the usual assumption of 2.5 m.p.h.

2. The ease with which the number of horses used may be varied to suit the draft requirements of an implement is an important advantage of horse operated implements which is not usually stressed.

3. As the draft of any implement varies with soil types, depth and soil condition, the tractor operated machine must be of a size that its draft under the worst conditions will not exceed the tractor's capacity. This means that under more favourable conditions the tractor will be underloaded as shown in these tests.

4. There is definite need for more information as to the draft requirements of the various farm implements.

5. A draft survey of the various soil types in Manitoba is urgently needed if farmers are to obtain the maximum efficiency from either horses or tractors.

## SUMMARY

The draft tests made during the survey show conclusively that the average operator has little idea of the power being developed by his horses or tractor. In the case of horse drawn implements we have an example of three horses pulling the same load as six horses and of four horses pulling practically as much as eight horses. In so far as horse operators are concerned the odds seem to be just as great that the horses will be overloaded as underloaded.

With tractors a fixed maximum cannot be exceeded, and as a close approach to this results in operating difficulties, practically all tractors tested were found to be underloaded. No simple method for determining when the tractor has an adequate load is available to the farmer, and therefore the average tractor in these tests was found to be operating with an inefficient load.

## RESUME

L'EMPLOI EFFICACE DE L'ÉNERGIE MOTRICE SUR LA FERME. H. R. Robson et G. L. Shanks, Université du Manitoba, Winnipeg, Man.

Les essais de traction qui ont été effectués ont démontré de façon concluante que le conducteur ordinaire ne se fait qu'une idée très vague de l'énergie développée par ses chevaux ou ses tracteurs. Dans le cas de machines tirées par des chevaux, nous avons un exemple de trois chevaux tirant la même charge que six chevaux, et de quatre chevaux tirant à peu près autant que huit chevaux. En ce qui concerne les conducteurs de chevaux, il y a tout autant de chance pour les chevaux d'être surchargés que d'être trop peu chargés. Avec les tracteurs on ne peut pas dépasser un maximum fixé, et comme on éprouve des difficultés de conduite lorsqu'on se rapproche de ce maximum, presque tous les tracteurs essayés ont été trouvés sous-chargés. Il n'existe pas de moyen simple pour déterminer si le tracteur a une charge suffisante, et c'est pourquoi on a trouvé que le tracteur ordinaire dans ces essais fonctionnait avec une charge inefficace.

# CEREAL GRAIN CROPS FOR ANNUAL PASTURE

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[Received for publication May 5, 1934]

Annual pasture crops are important in many parts of Canada. In the prairie provinces perennial grasses and legumes cannot be depended upon to supply grazing during the periods of dry weather which occur almost every season. This is the case also, though not to the same extent, in Ontario and Quebec. The most feasible method of overcoming this difficulty is to seed one of the grain crops to provide pasturage when the perennial grasses are unproductive.

The cereals used as annual pasture crops are oats, barley, wheat, and spring rye, oats being by far the most important for this purpose. Barley is used also to a considerable extent. Spring rye is seeded for pasture in the driest sections of the West and wheat is sometimes used when other seed is not available. Sometimes two or more of the cereal grains are mixed. Another favorite combination is a mixture of oats and fall rye, the latter to supply green vegetation in the autumn after the oats are eaten off, or harvested for green feed.

There are certain questions relating to the use of cereal grains for pasture that have not been investigated. Definite information is lacking on the relative productivity and nutrient value of the different cereals. It is not known which of them has the greatest power of regrowth after being eaten off and which of them will produce the greatest number of pasture crops in a single season. Several other questions also require answering. What is the best time to begin pasturing? How does the percentage of protein in the herbage compare at different stages of growth? Will the fresh young growth provide a high protein feed as is the case with perennial grasses, and if so is the total seasonal yield of protein satisfactory? Are the results better with early than with late seeding, and how do the different cereal crops compare in this respect?

In order to answer these questions an experiment was started in the spring of 1932 at the Dominion Experimental Farm, Indian Head, Saskatchewan. Four cereals were grown, namely, oats, barley, wheat and spring rye. These were cut with a horse mower to simulate grazing. Provision was made for five plots of each cereal, clipping to begin at different stages of growth, approximately as follows, and thereafter as often as the growth reached a height of 7 to 8 inches: (1) 3–leaf stage; (2) 5–leaf stage; (3) shot blade; (4) early heading; (5) fully headed. The 3–leaf stage corresponded to a height 4 to 5 inches and the 5–leaf stage to a height of 6 to 8 inches. These measurements refer to the leaf mass. If the full length of the leaves had been measured, the heights would have been considerably more than those stated. One series in duplicate (designated first and second series) was seeded early, about May 20, and a second seeding in duplicate was started late, about June 12. All samples were air-dried and forwarded to the Dominion Experimental Farm at Ottawa, where dry matter and protein analyses of the herbage were made by the Division of Chemistry. Two years' records are now available from this experiment, and results of considerable interest have been obtained.

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[3] Assistant Chemist, Division of Chemistry, Central Experimental Farm, Ottawa, Ontario.

The season of 1932 differed considerably from that of 1933 with respect to the amount and distribution of rainfall. Precipitation from April to July inclusive was almost equal to the 25 year average, but the season began with practically no reserve soil moisture and it was very dry up until May 22. After this date the supply of moisture was satisfactory until the middle of July. Late July and early August was exceedingly hot and dry but the rainfall for the month of August was above average. The season of 1933, on the other hand, was much more favourable for forage crops. Plenty of snow cover during the winter of 1932-1933 provided excellent growing conditions at time of seeding and good rains were received at fairly regular intervals during May and June.

## EXPERIMENTAL DATA

The yield data on dry matter and protein from the first and second series for both the early and late seedings are summarized in Tables 1, 2 and 3. Table 1 contains the data for the early seeding, Table 2 for the late seeding, and Table 3 gives averages for dates of seeding and duplicate series in 1932-1933. In all three tables the data are presented for each stage of growth when clipping of the plots was begun.

Average yields of dry matter per acre and protein percentages for the early seeding of the different cereal crops are shown graphically in Figure 1. The "stage of growth" indicates the vegetative period when clipping was begun and the yields for each vegetative period include all subsequent clippings. It is apparent that the total yield of dry matter increased as the stage of growth advanced, whereas the percentage of protein became less as the first cutting was delayed. As the yield of dry matter increased, the protein content decreased. This was the case with all four cereal crops.

Figure 2 gives the data corresponding to that shown in Figure 1, but for a later date of seeding. The trends in yields of dry matter and protein content were almost identical but the yields of the former were less. It is worthy of note that in both graphs, and with respect to both the yield and protein content, the four crops maintain the same order from highest to lowest, namely oats, barley, wheat, rye.

Figures 3 and 4 show the total yields of protein per acre for the early and late seedings respectively of the four cereal crops. These graphs are the more significant because they combine yield of dry matter with protein content and present a substantially true picture of the relative feeding value of each crop when utilized as pasture. The outstanding value of oats is clearly evident. Barley comes next, followed by wheat and spring rye. The advantage of early seeding was more pronounced in the case of oats than in that of the other cereals due in part at least to its ability to produce a larger number of successive crops of herbage.

In the case of oats at the early date of seeding, it is apparent that the maximum yield of protein per acre was obtained when cutting was begun at the 5-leaf stage. At the later date of seeding, the 3-leaf stage was somewhat better than the 5-leaf stage. In the case of wheat and rye,

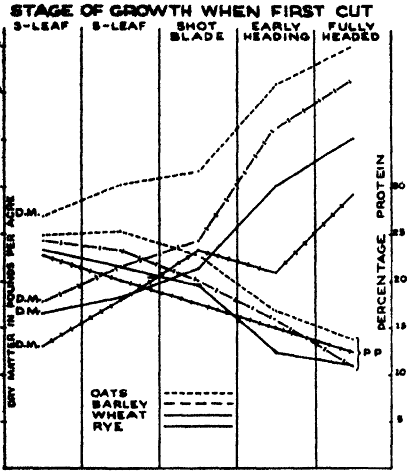

FIGURE 1. Graph showing the total average seasonal yields of dry matter and the protein percentages as determined for the first cutting at the stage of growth indicated, including all successive pasture cuts. (Early seeding: 1932 and 1933.)

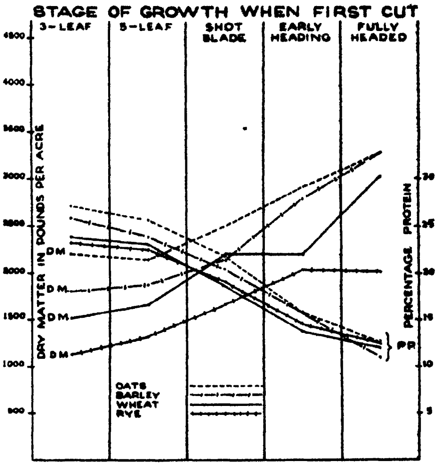

FIGURE 2. Graph showing the total average seasonal yields of dry matter and the protein percentages as determined for the first cutting at the stage of growth indicated, including all successive pasture cuts. (Late seeding: 1932 and 1933.)

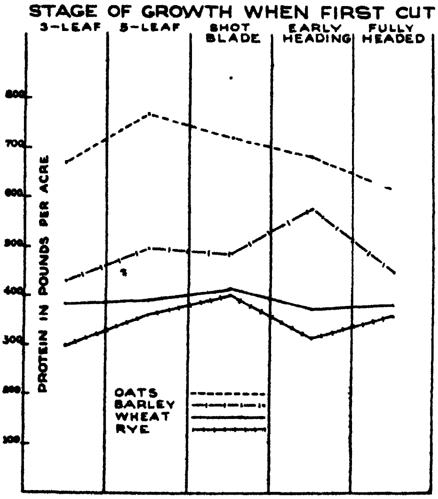

FIGURE 3. Graph showing the total average seasonal yields of protein as determined for the first cutting at the stage of growth indicated, including all successive pasture cuts. (Early seeding: 1932 and 1933.)

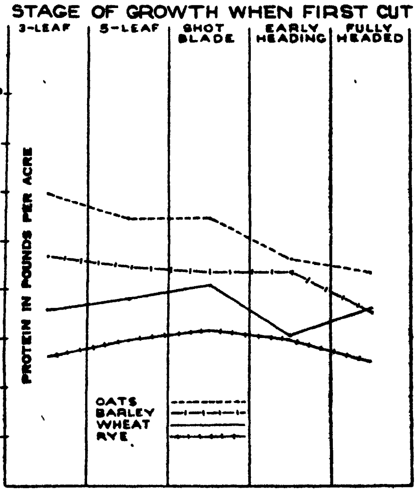

FIGURE 4. Graph showing the total average seasonal yields of protein as determined for the first cutting at the stage of growth indicated, including all successive pasture cuts. (Late seeding: 1932 and 1933.)

largest yields were obtained by starting to cut when the plants were in the shot blade. The results with barley were less consistent and it is difficult to account in Figure 3 for the high point reached by this crop at early heading.

In view of the evident superiority of oats for pasture over the other three cereals, it seemed worth while to set forth diagramatically the yields of dry matter and of protein per acre which were obtained from each of the cereal crops at each cutting. By so doing a picture could more easily be obtained of the number of pasture cuts per season and the consistency with which these were maintained throughout the season. The latter is a measure of the power of regrowth possessed by the different cereals. Figures 5 and 6 give this information with respect to acre yields of dry matter and protein respectively when cutting was begun at the 3–leaf stage. Figures 7 and 8 present the same data when cutting was started at the 5–leaf stage. Figures 5 to 8 inclusive refer to the early date of seeding only, and each shows the comparative yields for 1932 and 1933 as well as the average results for these years.

It is almost unnecessary to detail the significant features which are so clearly evident in these diagrams. Oats invariably gave the lowest yield at the first cut but the productivity of this crop was much the best sustained. In 1932, when cutting was begun at the 3–leaf stage, oats produced 5 cuts as compared with 4 for barley, wheat and rye. In 1933 oats gave 7 cuttings as compared with 4 for the other crops. The smallness of the first cut in 1932 was due to the very dry weather conditions in the spring, while moisture conditions were excellent in the spring of 1933 resulting in good growth from the start. It is very noticeable that oats continued to produce substantial yields after the other cereals had ceased to grow. The best single comparison may be made by an examination of the total average yields of protein per acre. These are shown in Figures 6 and 8.

## Discussion of Results

The superiority of oats as the one best annual hay crop has been generally recognized throughout Canada and experimental investigations have strongly supported practical experience in this connection. It is not so clearly appreciated, however, that oats are also the best annual pasture crop. The data submitted herein supports the view that the oats crop is even more valuable for pasture than for hay as compared with the other cereals. This is clearly shown in Figure 3 when the spread in yield at the 5–leaf stage of growth is compared with the spread in yield when the oats are fully headed. Such a comparison is legitimate since the last stage of growth at which the cereals were cut is comparable to the vegetative period at which they should be cut for hay. It should be pointed out also that the total yield reported for oats at the "fully headed" stage includes an appreciable amount of aftermath which would not normally be included in the yield of hay.

If we take the 5–leaf stage of growth as an appropriate basis of comparison between oats and the other cereals for pasture purposes, it will be seen from an examination of Figures 3 and 4 that the total yield of protein per acre in early seeded oats exceeded that of barley by about 54%, wheat by 96% and spring rye by 112%. At the later date of seeding oats exceeded

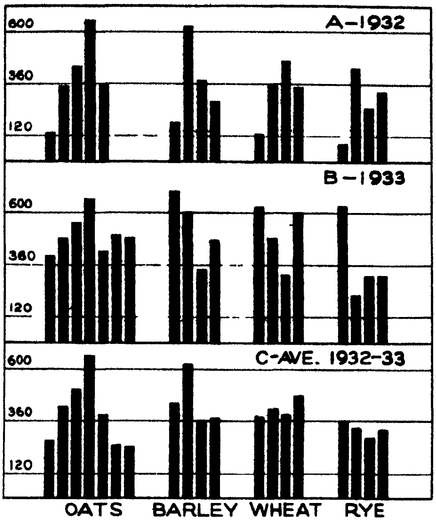

FIGURE 5. Yields of dry matter in pounds per acre from successive cuttings beginning at the three-leaf stage. (Early seeding.)

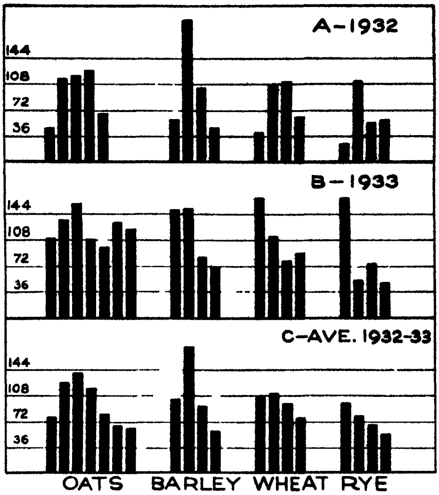

FIGURE 6. Yield of protein in pounds per acre from successive cuttings beginning at the three-leaf stage. (Early seeding.)

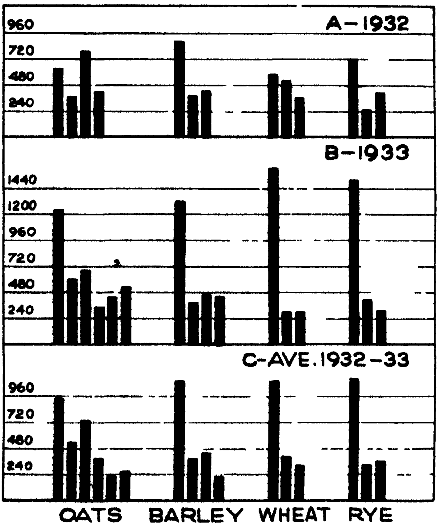

FIGURE 7. Yields of dry matter in pounds per acre from successive cuttings beginning at the five-leaf stage. (Early-seeding.)

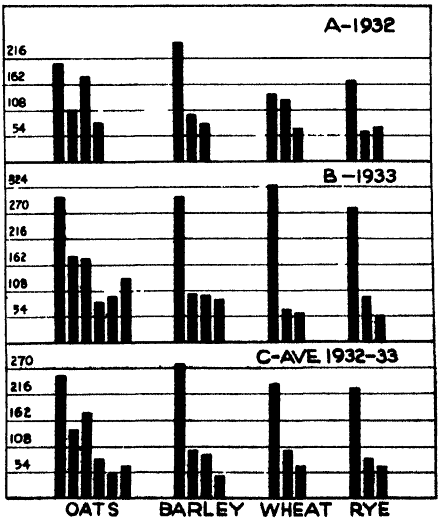

FIGURE 8. Yields of protein in pounds per acre from successive cuttings beginning at the five-leaf stage. (Early seeding.)

TABLE 1.—SEASONAL YIELDS OF DRY MATTER AND PROTEIN IN POUNDS PER ACRE FROM THE EARLY SEEDING*

| Crop | Stage of growth at first cutting | 1932 | | | | | | 1933 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1st Series | | | 2nd Series | | | 1st Series | | | 2nd Series | | |
| | | No. times cut | Dry matter | Protein | No. times cut | Dry matter | Protein | No. times cut | Dry matter | Protein | No. times cut | Dry matter | Protein |
| Oats | 3–leaf | 5 | 1826 | 500 | 5 | 1961 | 454 | 7 | 3664 | 921 | 7 | 3323 | 813 |
| | 5–leaf | 4 | 2362 | 628 | 4 | 2034 | 511 | 6 | 4228 | 1058 | 6 | 3486 | 872 |
| | Shot blade | 3 | 2060 | 439 | 3 | 1792 | 325 | 5 | 4418 | 1063 | 5 | 4397 | 1059 |
| | Early heading | 2 | 2754 | 431 | 2 | 2901 | 449 | 4 | 5565 | 961 | 4 | 5161 | 895 |
| | Fully headed | 1 | 3223 | 477 | 1 | 3347 | 429 | 2 | 5813 | 791 | 2 | 5719 | 776 |
| Barley | 3–leaf | 4 | 1556 | 466 | 4 | 1358 | 352 | 4 | 2373 | 510 | 4 | 1853 | 400 |
| | 5–leaf | 3 | 1890 | 491 | 3 | 1512 | 351 | 4 | 2703 | 604 | 4 | 2472 | 558 |
| | Shot blade | 2 | 2321 | 438 | 2 | 855 | 154 | 3 | 3227 | 667 | 3 | 3299 | 686 |
| | Early heading | 1 | 2543 | 383 | 1 | 2614 | 394 | 2 | 4799 | 730 | 2 | 4546 | 696 |
| | Fully headed | 1 | 3977 | 520 | 1 | 1669 | 195 | 1 | 5368 | 524 | 1 | 5586 | 545 |
| Wheat | 3–leaf | 4 | 1537 | 409 | 4 | 1025 | 235 | 4 | 2282 | 503 | 4 | 1747 | 389 |
| | 5–leaf | 3 | 1741 | 409 | 3 | 1181 | 257 | 3 | 2545 | 521 | 3 | 1806 | 374 |
| | Shot blade | 2 | 2331 | 412 | 2 | 1306 | 230 | 3 | 2649 | 545 | 2 | 2210 | 468 |
| | Early heading | 1 | 2822 | 369 | 1 | 1890 | 247 | 2 | 4009 | 479 | 2 | 3339 | 398 |
| | Fully headed | 1 | 2451 | 304 | 1 | 1919 | 249 | 1 | 4934 | 504 | 1 | 4780 | 489 |
| Rye | 3–leaf | 4 | 1334 | 325 | 4 | 851 | 181 | 4 | 1903 | 424 | 4 | 1132 | 253 |
| | 5–leaf | 3 | 1642 | 372 | 3 | 1103 | 232 | 3 | 2434 | 468 | 3 | 2015 | 375 |
| | Shot blade | 2 | 2911 | 497 | 2 | 1498 | 255 | 2 | 2624 | 467 | 2 | 2252 | 402 |
| | Early heading | 1 | 2285 | 298 | 1 | 1655 | 215 | 2 | 2338 | 387 | 2 | 2093 | 350 |
| | Fully headed | 1 | 3173 | 340 | 1 | 1811 | 213 | 2 | 3611 | 477 | 1 | 3084 | 409 |

*Dates of seeding, May 21, 1932, and May 20, 1933.

TABLE 2.—SEASONAL YIELDS OF DRY MATTER AND PROTEIN IN POUNDS PER ACRE FROM LATE SEEDING*

| Crop | Stage of growth at first cutting | 1932 | | | | | | 1933 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1st Series | | | 2nd Series | | | 1st Series | | | 2nd Series | | |
| | | No. times cut | Dry matter | Protein | No. times cut | Dry matter | Protein | No. times cut | Dry matter | Protein | No. times cut | Dry matter | Protein |
| Oats | 3–leaf | 4 | 2086 | 574 | 4 | 1605 | 425 | 6 | 3171 | 861 | 6 | 1940 | 525 |
| | 5–leaf | 4 | 2064 | 531 | 2 | 1014 | 246 | 5 | 3150 | 811 | 4 | 2365 | 602 |
| | Shot blade | 3 | 1993 | 464 | 3 | 1420 | 376 | 4 | 3384 | 693 | 4 | 3259 | 672 |
| | Early heading | 2 | 2574 | 490 | 2 | 2025 | 384 | 2 | 4202 | 596 | 2 | 2905 | 380 |
| | Fully headed | 2 | 2811 | 348 | 2 | 3347 | 429 | 2 | 3961 | 508 | 2 | 3017 | 387 |
| Barley | 3–leaf | 3 | 1638 | 459 | 2 | 1121 | 300 | 5 | 2539 | 646 | 4 | 1928 | 469 |
| | 5–leaf | 3 | 1359 | 343 | 3 | 1476 | 334 | 4 | 2531 | 620 | 3 | 2088 | 487 |
| | Shot blade | 1 | 1975 | 397 | 1 | 758 | 152 | 2 | 2849 | 591 | 2 | 2962 | 608 |
| | Early heading | 1 | 2157 | 369 | 1 | 1544 | 264 | 2 | 4099 | 613 | 2 | 3380 | 507 |
| | Fully headed | 1 | 1669 | 195 | 1 | 1669 | 195 | 1 | 5017 | 536 | 1 | 4685 | 500 |
| Wheat | 3–leaf | 2 | 1146 | 282 | 2 | 780 | 187 | 4 | 2098 | 509 | 4 | 2016 | 457 |
| | 5–leaf | 2 | 1357 | 324 | 2 | 1087 | 211 | 3 | 2317 | 575 | 3 | 1857 | 416 |
| | Shot blade | 2 | 1986 | 358 | 2 | 985 | 182 | 2 | 3147 | 594 | 2 | 2716 | 506 |
| | Early heading | 1 | 1954 | 292 | 1 | 1634 | 244 | 1 | 2946 | 385 | 1 | 2278 | 298 |
| | Fully headed | 1 | 1319 | 171 | 1 | 1919 | 249 | 1 | 4624 | 527 | 1 | 4433 | 506 |
| Rye | 3–leaf | 2 | 1200 | 305 | 2 | 758 | 183 | 4 | 1806 | 399 | 4 | 787 | 170 |
| | 5–leaf | 2 | 1271 | 268 | 2 | 985 | 203 | 3 | 1599 | 380 | 3 | 1441 | 332 |
| | Shot blade | 2 | 1788 | 311 | 2 | 1166 | 203 | 2 | 2034 | 410 | 2 | 1670 | 340 |
| | Early heading | 2 | 1826 | 261 | 2 | 1733 | 256 | 2 | 2272 | 326 | 2 | 2328 | 334 |
| | Fully headed | 2 | 2534 | 318 | 1 | 1811 | 213 | 1 | 1981 | 255 | 1 | 1717 | 221 |

*Dates of seeding, June 14, 1932, and June 12, 1933.

TABLE 3.—AVERAGE YIELDS OF DRY MATTER AND PROTEIN IN POUNDS PER ACRE OF DUPLICATE SERIES AND DATES OF SEEDING FOR 1932–1933

| Cereal | Stage of growth at first cutting | May Sowing | | | | | | June Sowing | | | | Average 1932–33 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1932 1st and 2nd series | | 1933 1st and 2nd series | | Average 1932–33 | | 1932 1st and 2nd series | | 1933 1st and 2nd series | | | |
| | | Dry matter | Protein | Dry matter | Protein | Dry matter | Protein | Dry matter | Protein | Dry matter | Protein | Dry matter | Protein |
| Oats | 3–leaf | 1893 | 477 | 3493 | 867 | 2694 | 672 | 1845 | 499 | 2555 | 693 | 2201 | 596 |
| | 5–leaf | 2198 | 569 | 3857 | 965 | 3028 | 767 | 1539 | 388 | 2757 | 706 | 2148 | 548 |
| | Shot blade | 1926 | 382 | 4407 | 1061 | 3167 | 722 | 1706 | 420 | 3321 | 682 | 2514 | 551 |
| | Early heading | 2827 | 440 | 5363 | 928 | 4095 | 684 | 2300 | 437 | 3553 | 488 | 2927 | 463 |
| | Fully headed | 3285 | 453 | 5766 | 783 | 4526 | 618 | 3079 | 388 | 3489 | 447 | 3284 | 418 |
| Barley | 3–leaf | 1457 | 409 | 2113 | 455 | 1785 | 432 | 1379 | 379 | 2233 | 557 | 1807 | 469 |
| | 5–leaf | 1701 | 421 | 2587 | 581 | 2144 | 496 | 1417 | 338 | 2309 | 553 | 1864 | 446 |
| | Shot blade | 1588 | 296 | 3263 | 676 | 2426 | 486 | 1366 | 274 | 2905 | 599 | 2136 | 437 |
| | Early heading | 2578 | 388 | 4672 | 713 | 3626 | 576 | 1850 | 316 | 3739 | 560 | 2795 | 438 |
| | Fully headed | 2873 | 357 | 5477 | 534 | 4150 | 446 | 1669 | 195 | 4851 | 508 | 3260 | 357 |
| Wheat | 3–leaf | 1281 | 322 | 2014 | 446 | 1648 | 384 | 963 | 234 | 2057 | 483 | 1510 | 359 |
| | 5–leaf | 1461 | 333 | 2175 | 447 | 1818 | 390 | 1222 | 267 | 2087 | 495 | 1655 | 382 |
| | Shot blade | 1818 | 321 | 2449 | 506 | 2124 | 414 | 1485 | 270 | 2931 | 550 | 2209 | 410 |
| | Early heading | 2356 | 308 | 3674 | 438 | 3015 | 373 | 1794 | 268 | 2612 | 341 | 2203 | 305 |
| | Fully headed | 2185 | 277 | 4857 | 496 | 3521 | 387 | 1619 | 210 | 4528 | 516 | 3024 | 363 |
| Rye | 3–leaf | 1092 | 253 | 1517 | 338 | 1306 | 296 | 979 | 244 | 1296 | 284 | 1138 | 264 |
| | 5–leaf | 1372 | 302 | 2224 | 421 | 1798 | 362 | 1128 | 235 | 1520 | 356 | 1324 | 296 |
| | Shot blade | 2204 | 376 | 2438 | 434 | 2321 | 405 | 1477 | 257 | 1852 | 375 | 1665 | 316 |
| | Early heading | 1970 | 256 | 2215 | 368 | 2093 | 313 | 1779 | 258 | 2300 | 330 | 2040 | 294 |
| | Fully headed | 2492 | 276 | 3347 | 443 | 2920 | 360 | 2172 | 265 | 1849 | 238 | 2011 | 252 |

barley in yield of protein per acre by 23%, wheat by 53%, and spring rye by 85%. Oats proved to be much the better pasture crop, therefore, whether they were compared on the basis of early or late seeding. Their superiority, however, was most pronounced with early seeding.

The total seasonal yield of oats herbage from the early seeding when cutting began at the 5-leaf stage was slightly over 3,000 pounds per acre and the average protein content for all cuttings was about 25%. The corresponding yield at the same stage of growth for the later seeding was about 2,500 pounds with a similar protein content. In both cases the average time between the first and last cuttings was approximately 80 days. The larger yield of 3,000 pounds would be equivalent to a carrying capacity of 100 cow days or 1.25 cows per day for the 80 day period. Pasture experiments conducted at the Central Experimental Farm, Ottawa, by the Divisions of Animal Husbandry and Field Husbandry, over a period of 5 years, have shown that first class blue grass pasture had an average carrying capacity of 70 cow days per season. An adjacent fertilized area had a carrying capacity of 90 cow days. The average protein content based on samples of the herbage taken at monthly intervals during each of three seasons was 20%. The comparison between oats and blue-grass is very favourable to the former with respect to both yield and protein content. It is true that the oats were grown in Saskatchewan and the blue-grass in Ontario, but this does not make the comparison any less interesting or significant.

Experiments on three fields to determine the carrying capacity of cereals as annual pasture crops under actual grazing conditions were begun in 1933 at the Dominion Experimental Farm, Indian Head. The results tend to substantiate our estimate of the carrying capacity based on the yields from clipped plots. It will be necessary to repeat these tests for three or four years in order to obtain reliable data. A pasture experiment also with perennial species on four fields was laid down in 1933 and this will be subjected to controlled grazing in 1934. This will make it possible to obtain a comparison between oats on the one hand and on the other, brome grass, western rye grass, crested wheat grass, and a mixture of all the grasses with alfalfa.

When oats are used as an annual pasture crop, too often they are not grazed in practice until the early heading or fully headed stage of growth. The question arises as to whether cereal crops, and oats in particular, should not be subjected to grazing at an earlier stage of development. Generally speaking, of course, supplementary pastures will be utilized when they are needed, but assuming that additional pasturage is required, it is important to know how soon pasture may be or should be grazed to produce satisfactory results. There is also the question as to what will be the effect of early grazing on the total yield of nutrients and whether early grazed oat herbage will provide an adequate protein-rich diet together with a satisfactory bulk of organic matter.

From the results of this experiment it is evident that early seeded oats has produced the greatest yields of protein per acre when cutting began at the 5-leaf stage. Later seeding gave the largest yields when cutting was started at the 3-leaf stage. In the latter case growth was more rapid from the beginning due to higher temperatures, but the seasonal yield was considerably less. It would appear, therefore, that, with proper management, the grazing of oats should begin about the 5–leaf stage in order to secure the maximum feeding value. The same cannot be said of any of the other cereals, but the data shows that any of these crops can be pastured at an early stage of growth if so desired without reducing the total yield of protein. It is recognized that when fields are grazed there will be a certain amount of wastage but this can be very largely avoided by good management in handling the live stock. On the other hand, grazing has some advantages over cutting as the latter treatment, being rather drastic, tends to suppress growth.

The relative amounts of dry matter in the fresh cut herbage merit some attention from a pasture standpoint. Considering only the two earliest cuts beginning at the 3-and 5–leaf stages of growth from both the early and late seedings it was found that the average percentage of dry matter for oats, barley, wheat and rye was 14.2, 15.3, 18.2 and 18.0% respectively. This shows that the oats and barley were more succulent than the wheat and rye and it also raises the question whether animals could consume a sufficient quantity of oats or barley herbage at these early stages of growth to give them the amount of feed which they need.

A dairy cow on full ration requires in the neighbourhood of 30 pounds of dry matter in each 24 hours. Assuming that she had access only to the fresh young herbage of annual pasture crops containing 15% of dry matter, she would have to consume 200 pounds of green material per day. Whether she could do this or not is open to question but it is a fact that animals will eat a considerably larger quantity of fresh young herbage as pasture than if the same material were supplied to them in the wilted or dry condition. Apart from the bulkiness of the feed, this degree of succulence in a sole ration is undoubtedly undesirable because of its laxative effect as compared with one of a higher dry matter content. It would seem, and experience indicates, that if animals are to be grazed on young herbage with such a high moisture content they should be provided with a certain amount of dry feed as well. On account of the high protein content oats pasture at the early stages of growth admits of this without unduly lowering the protein content, and the addition of dry roughage or other carbonaceous feed as a pasture supplement will tend to provide a better balanced ration.

The high protein content of fresh young herbage of the cereal crops is worthy of special consideration from a feeding standpoint. Figures 1 and 2 show the relative protein content at the different stages of plant development. With all crops, the decrease is consistently downward after the 5–leaf stage. At this stage oats contain an average of 25% of crude protein and it does not fall below 20% until after the shot blade stage is reached. These facts definitely place young oat herbage in the class of a highly concentrated protein feed. The protein of young grass is approximately 75% digestible and assuming that the same applies to oats we can say that the oat herbage in the leafy stages contains sufficient digestible nutrients to supply the requirements of the heaviest producing milch cows. As a matter of fact, a 1,000 lb. cow producing 3 gallons of milk per day would have an adequate protein diet if only one-half of her ration was derived from oat pasture and the other half from hay or other roughage.

Recognition of the fact that young oat pasturage may be regarded as a protein concentrate should enable the feeder, under certain conditions to reduce his outlay for commercial feeds, or provide additional pasturage in critical periods. As a rule there is no lack of pasture during the flush of growth in the early part of the season but sometimes this is not the case and almost invariably the pastures fail in July and August. Under these circumstances it is well to know the relative value of annual crops for pasture and to appreciate the excellence of oats for this purpose.

## SUMMARY

1. Oats, barley, wheat and spring rye were compared with reference to yield, feeding value and utilization as annual pasture crops.

2. With respect to yield of dry matter per acre and percentage of protein, oats were always superior to barley, followed in order by wheat and spring rye.

3. In total average yield of protein per acre from the early seeding, oats exceeded barley by 54%, wheat by 96%, and spring rye by 112%. At the later date of seeding oats exceeded barley by 23%, wheat by 53%, and rye by 85%.

4. The total pasture yield of all crops increased and the percentage protein decreased as the first date of cutting was delayed.

5. Oats had a lower dry matter content than the other cereal crops.

6. Oats produced 5 cuttings in 1932 and 7 cuttings in 1933 as compared with 4 cuttings in both seasons by the other three crops.

7. Largest yields of protein per acre were obtained from oats when pasture cuttings were begun at the 5–leaf stage.

8. Oats from the early seeding produced 3,000 pounds of dry matter per acre with an average protein content of 25%. This is equivalent to a greater carrying capacity than was obtained at Ottawa on good quality native blue-grass sod.

9. Young oats herbage may be regarded as a highly concentrated protein feed.

## RESUME

CÉRÉALES POUR PÂTURAGES ANNUELS. L. E. Kirk, J. G. Davidson et Stella N. Hamilton, Ferme expérimentale fédérale, Indian Head, Saskatchewan.

L'avoine, l'orge, le blé et le seigle de printemps ont été comparés l'un à l'autre pour le rendement, la valeur alimentaire et l'utilisation comme plantes annuelles à pacage. En ce qui concerne le rendement de matière sèche par acre et le pourcentage de protéine, l'avoine s'est toujours montrée supérieure à l'orge; viennent ensuite le blé et le seigle de printemps. Au point de vue du rendement moyen total de protéine par acre dans la récolte provenant des premières semailles, l'avoine a dépassé l'orge par 54%, le blé par 96% et le seigle de printemps par 112%. Dans la récolte provenant des dernières semailles, l'avoine a dépassé l'orge par 23%, le blé par 53% et le seigle par 85%. Le rendement total en pâturage de toutes les récoltes augmentait tandis que le pourcentage de protéine diminuait à mesure que la première date de coupe était retardée. L'avoine avait une proportion de matière sèche plus faible que les autres céréales. L'avoine a produit cinq coupes en 1932 et sept coupes en 1933, tandis que les trois autres récoltes donnaient quatre coupes dans les deux saisons. L'avoine a donné le rendement le plus élevé de protéine par acre lorsque les coupes ont été commencées quand la plante avait cinq feuilles. L'avoine des premières semailles a produit 3,000 livres de matière sèche par acre et une proportion moyenne de protéine de 25%. Ceci représente une quantité de nourriture plus forte que celle que l'on a obtenue à Ottawa sur gazon de pâturin indigène de bonne qualité. On peut en conclure que l'herbage de jeune avoine est un aliment protéique hautement concentré.

# THE ECONOMIC SITUATION

### PREPARED IN THE AGRICULTURAL ECONOMICS BRANCH, DEPARTMENT OF AGRICULTURE, OTTAWA, LARGELY FROM BASIC DATA COLLECTED BY THE DOMINION BUREAU OF STATISTICS

The index number of wholesale prices in Canada declined from 72.0 in March to 71.1 in April. The recessions in the vegetable products group and animals and their products were quite marked. The index of chemicals and allied products rose from 80.8 to 81.8, while that of iron and its products was unchanged, other subindexes moved downward.

*Retail Prices.*—The total index of retail prices, rents and costs of services receded from 80.2 in March to 79.6 in April. The index of prices of foods dropped from 72.9 to 71.0. The fuel index advanced from 87.3 to 87.6.

*Physical Volume of Business.*—The index of physical volume of business was 92.6 in April as compared with 93.1 in March. Industrial production moved downward from 92.0 to 91.4. Mineral production, car loadings and exports were higher. In the manufacturing group activity in automobile production was outstanding. Sugar output was also much higher than in the preceding month. Production of newsprint was just about maintained. Electric power was off slightly. Construction failed to show the anticipated gain. While production as a whole was not as active as in March, it will be recalled that the production indexes rose sharply between February and March of this year.

*Agricultural Products.*—The index of wholesale prices of Canadian farm products was 55.4 in April as against 56.5 in March, a decline of a little over one point. In the field products group the index fell from 49.7 to 48.7, lower prices for wheat, oats, barley and rye were chiefly responsible. Animal products dropped from 68.3 to 66.6, lower prices for hogs, calves, wool and eggs more than offset advances in the prices of cattle, fresh milk, hides and skins.

The primary movement of wheat was 196,754,313 bushels during the period August 1, 1933, to May 4, 1934. In 1932-33, during the corresponding period, 331,716,868 bushels were marketed.

The live stock market report published by the Live Stock Branch of the Federal Department of Agriculture states that for 21 weeks of 1934 ended May 24, sales of cattle at public yards were 238,166 head as compared with 204,913 for the same period of 1933. Sales of calves for the corresponding periods were 140,611 as against 119,717, those of sheep 74,314 where as in 1933, they were 77,631. Shipments of hogs both to public yards and direct to packing plants were 1,339,845, while in 1933 during this period 1,353,323 hogs were sold through these outlets.

During April agricultural marketings declined to 56.9. The index of grain marketings dropped from 58.7 in March to 49.3. There was an increase in the movement of live stock, the index rising from 86.4 to 90.6.

The index of cold storage holdings at the first of April stood at 94.5, this index, however, rose to 102.6 at the first of May, increased stocks of butter, veal and poultry were reported, whereas stocks of lard declined.

*Exports of Agricultural Products.*—Exports of Canadian agricultural and vegetable products for the twelve months ending March, 1934 were valued at $205,804,526 as compared with $203,370,418 during the twelve months period ending March, 1933. The volume of exports of the more important agricultural products during these two periods is set forth in Appendix Table 1.

Examination of Appendix Table 1 shows clearly that exports of apples, canned fruits, potatoes, canned vegetables, wheat flour, flax seed, cattle, bacon and hams, fresh beef, canned meats, eggs and wool have increased in volume. The decreases have taken place in fruit juices and syrup, barley, oats, rye, wheat, maple sugar, tobacco leaf and cheese. Among these products, the reduction in exports of wheat and tobacco leaf is most significant.

### ANNUAL AND MONTHLY INDEX NUMBERS OF PRICES AND PRODUCTION COMPUTED BY DOMINION BUREAU OF STATISTICS

| Year | Wholesale Prices 1926 = 100 | | | | Retail prices and cost of services (5) | Production (6) 1926 = 100 | | | |
|---|---|---|---|---|---|---|---|---|---|
| | All commodities (1) | Farm products (2) | Field products (3) | Animal products (4) | | Physical volume of business | Industrial production | Agricultural marketings | Cold Storage holdings |
| 1913 | 64.0 | 62.6 | 56.4 | 77.0 | 65.4 | | | | |
| 1914 | 65.5 | 69.2 | 64.9 | 79.0 | 66.0 | | | | |
| 1915 | 70.4 | 77.7 | 76.9 | 79.2 | 67.3 | | | | |
| 1916 | 84.3 | 89.7 | 88.4 | 92.3 | 72.5 | | | | |
| 1917 | 114.3 | 130.0 | 134.3 | 119.6 | 85.6 | | | | |
| 1918 | 127.4 | 132.9 | 132.0 | 134.7 | 97.4 | | | | |
| 1919 | 134.0 | 145.5 | 142.4 | 152.5 | 107.2 | 71.3 | 65.5 | 48.1 | 47.1 |
| 1920 | 155.9 | 161.6 | 166.5 | 149.9 | 124.2 | 75.0 | 69.9 | 52.6 | 94.2 |
| 1921 | 110.0 | 102.8 | 100.3 | 108.5 | 109.2 | 66.5 | 60.4 | 65.2 | 86.4 |
| 1922 | 97.3 | 86.7 | 81.3 | 99.1 | 100.0 | 79.1 | 76.9 | 82.6 | 82.8 |
| 1923 | 98.0 | 79.8 | 73.3 | 95.1 | 100.0 | 85.5 | 83.8 | 91.4 | 87.6 |
| 1924 | 99.4 | 87.0 | 82.6 | 97.2 | 98.0 | 84.6 | 82.4 | 102.5 | 114.9 |
| 1925 | 102.6 | 100.4 | 98.1 | 105.7 | 99.3 | 90.9 | 89.7 | 97.2 | 108.6 |
| 1926 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.9 | 100.0 |
| 1927 | 97.7 | 102.1 | 99.9 | 105.7 | 98.4 | 106.1 | 105.6 | 103.6 | 110.0 |
| 1928 | 96.4 | 100.7 | 92.6 | 114.3 | 98.9 | 117.3 | 117.8 | 146.7 | 112.8 |
| 1929 | 95.6 | 100.8 | 93.8 | 112.5 | 99.9 | 125.5 | 127.4 | 101.1 | 109.6 |
| 1930 | 86.6 | 82.3 | 70.0 | 102.9 | 99.2 | 109.5 | 108.0 | 103.0 | 128.4 |
| 1931 | 72.2 | 56.3 | 43.6 | 77.6 | 89.6 | 93.5 | 90.4 | 99.0 | 125.7 |
| 1932 | 66.7 | 48.4 | 41.1 | 60.7 | 81.4 | 78.7 | 74.0 | 114.3 | 120.1 |
| 1933 | | | | | | | | | |
| Jan. | 63.0 | 43.6 | 35.1 | 57.9 | 79.1 | 68.1 | 62.2 | 56.1 | 112.0 |
| Feb. | 63.6 | 43.0 | 36.0 | 54.7 | 78.4 | 67.0 | 60.0 | 76.5 | 127.6 |
| Mar | 64.4 | 44.7 | 38.0 | 56.0 | 77.8 | 68.4 | 62.5 | 129.0 | 135.8 |
| April | 65.4 | 46.8 | 41.1 | 56.4 | 78.1 | 69.8 | 65.1 | 104.1 | 112.7 |
| May | 66.9 | 51.2 | 46.9 | 58.4 | 77.0 | 76.4 | 72.7 | 95.4 | 110.4 |
| June | 67.6 | 52.6 | 49.4 | 57.9 | 77.0 | 82.2 | 79.8 | 221.9 | 119.9 |
| July | 70.5 | 60.1 | 60.8 | 59.0 | 77.2 | 84.1 | 82.6 | 221.9 | 119.9 |
| Aug. | 69.4 | 57.0 | 54.9 | 60.5 | 78.6 | 89.8 | 89.5 | 197.2 | 114.2 |
| Sept. | 68.9 | 54.7 | 49.5 | 63.4 | 78.8 | 90.8 | 90.2 | 101.1 | 115.7 |
| Oct. | 67.9 | 51.4 | 44.6 | 62.8 | 77.9 | 88.2 | 87.4 | 70.5 | 112.7 |
| Nov. | 68.7 | 53.8 | 46.7 | 65.8 | 78.1 | 85.5 | 83.9 | 41.8 | 111.1 |
| Dec. | 69.0 | 53.3 | 45.3 | 66.6 | 78.4 | 86.2 | 85.1 | 30.7 | 107.6 |
| 1934 | | | | | | | | | |
| Jan. | 70.6 | 55.3 | 47.9 | 67.8 | 78.7 | 86.8 | 84.5 | 48.2 | 108.1 |
| Feb. | 72.1 | 58.0 | 49.3 | 72.5 | 79.2 | 86.4 | 84.0 | 67.1 | 98.6 |
| Mar. | 72.0 | 56.5 | 49.5 | 68.3 | 80.2 | 93.1 | 92.0 | 63.8 | 97.0 |
| Apr. | 71.1 | 55.4 | 48.7 | 66.6 | 79.6 | 92.6 | 91.4 | 56.9 | 94.5 |

1. See Prices and Price Indexes 1913-1928, pp. 19-21, 270-289 and 1913-1931, p. 15.

2. Wholesale prices of Canadian products of farm origin only. See Prices and Price Indexes 1913–1931, p. 33, and Monthly Mimeographs 1933 and 1934.

3. Wholesale prices of grains, fruits and vegetables.

4. Wholesale prices of Animals and Animal Products.

5. Including foods, rents, fuel, clothing and sundries, See Prices and Price Indexes 1913-1928, pp. 181-185, 290-293. 1926=100.

Prices and Price Indexes 1913-1931, p. 122, and Monthly Mimeographs 1933-1934.

6. Monthly Review of Business Statistics, p. 8, and Monthly Indexes of the Physical volume of business in Canada, supplement to the Monthly Review of Business Statistics, November, 1932.

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*Prices in United States.*—The index of wholesale prices in United States (1910–14 = 100) was 108 in March of this year, the farm price index for all groups of agricultural products was 74.0 as compared with 56.0 in April, 1933.

### APPENDIX TABLE 1

VOLUME OF EXPORTS OF PRINCIPAL CANADIAN FARM PRODUCTS IN THE TWELVE MONTHS PERIODS ENDING MARCH 1933 AND 1934[1]

| Product | Unit | Amount |  | Product | Unit | Amount |  |
|---|---|---|---|---|---|---|---|
|  |  | 1933 | 1934 |  |  | 1933 | 1934 |
| Apples, fresh | bbls. | 1,780,026 | 3,476,114 | Wheat flour | bbls. | 5,268,371 | 5,619,937 |
| Fruit, canned | lbs. | 9,787,956 | 17,547,577 | Maple sugar | lbs. | 3,176,471 | 2,295,042 |
| Fruit juices |  |  |  | Clover seed | bush. | 68,121 | 117,405 |
| and syrups | gals. | 423,168 | 300,318 | Flax seed | bush. | 371,438 | 610,327 |
| Potatoes | bush. | 1,861,843 | 2,707,693 | Tobacco leaf | lbs. | 14,748,069 | 8,460,639 |
| Turnips | bush. | 1,950,482 | 1,949,022 | Cattle | No. | 37,359 | 64,209 |
| Canned |  |  |  | Bacon and |  |  |  |
| vegetables | lbs. | 6,755,112 | 17,099,688 | hams | cwt. | 402,101 | 960,178 |
| Barley | bush. | 9,863,054 | 1,569,569 | Beef, fresh | cwt. | 50,879 | 102,771 |
| Oats | bush. | 13,824,742 | 5,707,502 | Canned meats | cwt. | 602,966 | 973,218 |
| Rye | bush. | 8,211,332 | 2,788,213 | Cheese | cwt. | 857,116 | 749,669 |
| Wheat | bush. | 239,373,255 | 175,534,255 | Eggs | doz. | 270,340 | 2,122,904 |
| Bran, shorts, |  |  |  | Honey | lbs. | 2,679,536 | 2,306,248 |
| middlings | cwt. | 2,142,785 | 2,598,860 | Raw wool | — | 4,020,751 | 10,903,821 |

[1] Summary Trade of Canada, March, 1934.

## LA SITUATION ÉCONOMIQUE

PRÉPARÉ PAR LA DIVISION DE L'ÉCONOMIE AGRICOLE, DU MINISTÈRE DE L'AGRICULTURE, À OTTAWA, ET BASÉ PRINCIPALEMENT SUR LES DONNÉES RECUEILLIES PAR LE BUREAU FÉDÉRAL DE LA STATISTIQUE

L'indice des prix de gros au Canada, qui était de 72 0 en mars, est descendu à 71.1 en avril. La rétrogression dans le groupe des produits végétaux et les animaux et leurs produits a été très marquée. L'indice des produits chimiques et alliés s'est élevé de 80.8 à 81.8 tandis que celui du fer et de ses produits n'a pas changé. Les autres sous-indices ont baissé.

*Prix de détail.*—L'indice total des prix de détail, des loyers, et des frais de service est descendu de 80.2 en mars à 79 6 en avril. L'indice des prix des denrées alimentaires est descendu de 72.9 à 71.0. L'indice des combustibles est monté de 87.3 à 87.6.

*Indice du volume physique des affaires.*—L'indice du volume physique des affaires était à 92.6 en avril contre 93.1 en mars. La production industrielle est descendue de 92.0 à 91.4. La production minérale, les chargements de wagons et les exportations ont remonté. Dans le groupe manufacturier il y avait une grande activité dans l'industrie de l'automobile dont la production a été remarquable. La production du sucre a été également beaucoup plus élevée que le mois précédent. La production du papier à journal n'a fait que se maintenir. L'énergie électrique a un peu baissé. Le bâtiment n'a pas enregistré le gain que l'on attendait. La production en général n'a pas été aussi active qu'en mars, mais il est à noter que les indices de la production s'étaient élevés brusquement entre février et mars de cette année.

*Produits agricoles.*—L'indice des prix de gros des produits agricoles canadiens était de 55.4 en avril contre 56.5 en mars, soit une baisse d'un peu plus d'un point. Dans le groupe des produits des champs, l'indice est passé de 49.7 à 48.7, surtout à cause de la baisse des prix du blé, de l'avoine, de l'orge et du seigle. Les produits animaux, qui étaient à 68.3 sont descendus à 66.6, la baisse des prix pour les porcs, les veaux, la laine et les œufs a contrebalancé et au-delà les hausses enregistrées dans les prix des bovins, du lait frais, des cuirs et des peaux.

Le mouvement préliminaire du blé a été de 196,754,313 boisseaux entre le 1er août 1933 et le 4 mai 1934. Pendant la période correspondante en 1932-33 il s'était vendu 331,716,868 boisseaux.

Le rapport sur le commerce des bestiaux publié par la Division de l'Industrie animale du Ministère fédéral de l'Agriculture, établit que pendant les 21 semaines de 1934 finissant le 24 mai, les ventes de bovins aux marchés publics se sont chiffrées par 238,166 têtes contre 204,913 pendant la même période de 1933. Les ventes de veaux pendant la période correspondante ont été de 140,611 contre 119,717, celles de moutons de 74,314 contre 77,631 en 1933. Les expéditions de porcs aux marchés publics et directement aux salaisons ont été de 1,339,845 tandis qu'en 1933 pendant cette période il s'est vendu 1,353,323 porcs sur ces marchés.

En avril les ventes de produits agricoles sont tombées à 56.9. L'indice des ventes de grain qui était à 58.7 en mars est descendu à 49.3. Il y a eu une augmentation dans le mouvement des bestiaux, l'indice passant de 86.4 à 90.6.

Au 1er avril l'indice des produits entreposés au froid était de 94.5 puis il s'est élevé à 102.6 au 1er mai, à cause des stocks considérables de beurre, de veau et de volailles, tandis que les stocks de saindoux diminuaient.

*Exportations des produits agricoles.*—Pendant les douze mois finissant en mars 1934 les exportations de produits agricoles canadiens et végétaux ont été évaluées à $205,804,526 contre $203,370,418 pendant les douze mois finissant en mars 1933. Le volume des exportations des produits agricoles les plus importants pendant cette période est indiqué au tableau suivant.

VOLUME DES EXPORTATIONS DES PRINCIPAUX PRODUITS AGRICOLES CANADIENS PENDANT UNE PÉRIODE DE DOUZE MOIS FINISSANT EN MARS 1933 ET 1934 (¹)

| Produit | Unité | Valeur | | Produit | Unité | Valeur | |
|---|---|---|---|---|---|---|---|
| | | 1933 | 1934 | | | 1933 | 1934 |
| | | $ | $ | | | $ | $ |
| Pommes fraiches | barils | 1,780,026 | 3,476,114 | Farine de blé | barils | 5,268,371 | 5,619,937 |
| Conserves de fruits | liv. | 9,787,956 | 17,547,577 | Sucre d'érable | liv. | 3,176,471 | 2,295,042 |
| | | | | Graine de trèfle | boiss. | 68,121 | 117,405 |
| Jus de fruits et sirops | gal. | 423,168 | 300,318 | Graine de lin | boiss. | 371,438 | 610,327 |
| | | | | Tabac en feuilles | liv. | 14,748,069 | 8,460,639 |
| Pommes de terre | boiss. | 1,861,843 | 2,707,693 | Bestiaux | No. | 37,359 | 64,209 |
| Navets | boiss. | 1,950,482 | 1,949,022 | Bacon et jambon | qtx. | 402,101 | 960,178 |
| Conserves de légumes | liv. | 6,755,112 | 17,099,688 | Bœuf frais | qtx. | 50,879 | 102,771 |
| | | | | Conserves de viande | qtx. | 602,966 | 973,218 |
| Orge | boiss. | 9,863,054 | 1,569,569 | | | | |
| Avoine | boiss. | 13,824,742 | 5,707,502 | Fromage | qtx. | 857,116 | 749,669 |
| Seigle | boiss. | 8,211,332 | 2,788,213 | Œufs | douz. | 270,340 | 2,122,904 |
| Blé | boiss. | 239,378,255 | 175,534,255 | Miel | liv. | 2,679,536 | 2,306,248 |
| Son, gru blanc, gru rouge | qtx. | 2,142,785 | 2,598,860 | Laine brute | | 4,020,751 | 10,903,821 |

(¹) Sommaire du commerce canadien, mars 1934.

L'examen du tableau qui précède démontre clairement que les exportations de pommes, de conserves de fruits, de pommes de terre, de conserves de légumes, de farine de blé, de graine de lin, de bestiaux, de bacon et de jambons, de bœuf frais, de conserves de viande, d'œufs et de laine ont augmenté. Il y a eu des diminutions dans les jus de fruits et les sirops, l'orge, l'avoine, le seigle, le blé, le sucre d'érable, le tabac en feuilles et le fromage. Parmi ces produits, le blé et le tabac en feuilles sont ceux dont les exportations ont le plus diminué.

*Prix aux Etats-Unis.*—En mars de cette année l'indice des prix de gros aux Etats-Unis était de 108 (1910–14 = 100) l'indice des prix de ferme pour tous les groupes de produits agricoles était de 74.0 contre 56.0 en avril 1933.

# BOOK REVIEW

THE CANKER AND THE DRY ROT DISEASES OF SWEDES. W. Buddin, Brit. Min. Agr. Bull. 74. 1934.

The author gives an account of several years' investigations on two important diseases of swedes, viz. canker and dry rot, both caused by ***Phoma Lingam*** (Tode) Desm. The former is a disease of the seed-bearing plant, the etiology of which was not previously understood. The most conspicuous symptom is the formation of cankers at the soil line, which are not as a rule noticed until the plants are running to seed. Cankered plants are then easily broken off by the wind or during cultivation. Dry rot is a disease of the swede root crop. In Great Britain it is second to club root in importance, but in New Zealand its ravages have been considerable. Cunningham found that the disease was seed borne and alleged that it could be readily controlled if the seed imported into New Zealand, chiefly of British origin, was disease-free. The present author confirmed Cunningham's finding that the disease was seed borne. However, of the samples of commercial seed tested, about one-quarter showed an infection of 0.2%, while not more than 1 or 2% of the samples have shown as high as 1 to 3%. Moreover the seed possesses a definite fungous flora, and of the seven supposed strains of *P. Lingam* isolated by Cunningham, only two were of this organism, while the others were species of *Macrosporium*, *Alternaria*, *Diplodina*, etc. Three methods of testing for the presence of *P. Lingam* were used: agar plate, sowing in sterilized soil, and the Jacobsen germinator. The latter proved the best as only seed affected with *P. Lingam* became diseased. Cunningham, therefore, appears to have overestimated the extent of seed infection. While the author is of the opinion that seed treatment is of little value, it should be pointed out that certain organic mercury dusts applied at the rate of 6 oz. per bushel did not effect germination and reduced the percentage of diseased seedlings from 30 to 3%.

From observations made by the author and his co-workers, he concludes that sources of infection other than the seed are responsible for outbreaks of these diseases as they occur in England. Sowing of seed in the plant bed or in the field which was in swedes the previous season, leads frequently to serious outbreaks of these diseases. Several weeds including white mustard and charlock were shown experimentally to be susceptible and were found infected in the field. Although the main conclusions of the author may not be altered by subsequent researches, more information is desirable on the persistence of the disease in the soil. —I. L. Connors.

# NOTE

The editor of *Scientific Agriculture* regrets that in recent months it has not been possible to publish the magazine at the first of the month and therefore the value of "The Economic Situation" has been lessened to some extent. It is felt, however, that those who do not have access to the sources of information used, or who are unable to find time to read the various publications thoroughly, will appreciate this brief summary of conditions. As soon as the new plans for publication are fully in effect, it is hoped that the magazine will appear at the first of the month and "The Economic Situation" will then possess its customary usefulness.

SCIENTIFIC AGRICULTURE

Vol. XIV JULY, 1934 No. 11

# THE EVALUATION OF THE GERMICIDAL POTENCY OF CHLORINE COMPOUNDS. I. HYPOCHLORITES

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[Received for publication May 30, 1934]

The increasing popularity of chlorine sterilizing solutions during recent years has resulted in a growing number of commercial products being offered for sale. Not infrequently, laboratory workers are asked to report on the comparative efficiency of a series of these products from a germicidal standpoint, and the question arises as to the method of testing to be employed. Numerous workers (*2*, *6*, *8*, *10*, *11*, *12*, *13*, *14*, *17*, *19*, *20*, *21*, *22*, *26*, *27*, *28*, *29*, *30*) have reported the results of studies on chlorine sterilizing solutions, using a variety of methods. Many of these are open to the objection that they are better suited to research studies than to routine testing, as has been pointed out by Myers and Johnson (*17*). After reviewing the literature, these workers concluded that the method of the U. S. Food and Drug Administration (F.D.A. method) (*23*), using *Staphylococcus aureus* as test organism, was best adapted for practical evaluation of germicidal potencies. Using this method, results were obtained by them which were reasonably comparable to those from bottle rinsing tests in the case of hypochlorites (eleven hypochlorites were tested by the F.D.A. method and four of these were subjected to bottle rinsing tests); the single chloramine-T product, in contrast to the hypochlorites, required a greater concentration of chlorine in the bottle rinsing tests than in the test tube (F.D.A.) method against *Staph. aureus* but the reverse was true when *Eberthella typhi* was the test organism. In presenting their results, Myers and Johnson divide the eleven hypochlorites into two groups on the basis of the ratio of available chlorine to total alkalinity (as $Na_2O$); with the six products in the low alkalinity group (ratios 6 9 to 171.0) the "effective dilution" (that killing in ten minutes but not in five by the F.D.A. method) varied between 103 and 132 p.p.m. available chlorine, while for the five products in the high alkalinity group (ratios 0.189 to 1.69) the effective dilution ran between 285 and 301 p.p.m. Such a clear-cut grouping of these products as is indicated above appeared to be at variance with results previously reported from this laboratory (*12*), and as it became necessary about this time to conduct tests on a series of six hypochlorites and one chloramine-T product, an attempt was made to discover the reason for this lack of agreement.

## Experimental

### 1. F.D.A. METHOD AND MODIFICATIONS THEREOF

A culture of *Staphylococcus aureus* (U.S.D.A. No. 209) as employed by Myers and Johnson, was kindly furnished by Dr. R. P. Myers. This

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TABLE 1.—APPROXIMATE VALUES FOR EFFECTIVE CONCENTRATIONS OF CHLORINE STERILIZING PRODUCTS AS JUDGED BY THE F.D.A. METHOD AND MODIFICATIONS THEREOF

| Product | Ratio Av.Cl[1] / $Na_2O$ | Effective concentration (p.p.m. Av. Cl.) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Undiluted inoculum | | | | | | | | | Inoculum diluted 1/100 | | | |
| | | Broth[2] | | | | | Milk[2] | | | | Broth[2] | | Milk[2] | |
| B-K solution | 37 1 | 115[1] | 160, | 120, | 140, | 140 | >160, | >200, | >200 | — | < 10 | < 5 | < 10 | < 5 |
| HTH-15 | 0 554 | 285[1] | >320, | 360, | 320, | 320 | >320, | >440, | 480, | >440 | < 20 | < 10 | < 20 | < 10 |
| Chlorosil | 0 21 | 291[1] | >320, | 340, | 320 | — | >320, | 440, | — | 400 | 20 | 20? | 20? | < 20 |
| HTH-10 | — | — | >320, | 400, | 320 | — | >320, | >440, | 400 | — | 20? | 10 | 20? | 10 |
| Neomoscan | — | — | >320, | 420, | 360 | — | >320, | >440, | 480 | — | — | — | — | — |
| Diversol | 0 189 | 289[1] | >320, | 400, | 400, | 400 | >320, | >440, | 540, | 520 | 50? | < 50 | 50 | < 50 |
| Wyandotte Sterilizer[3] | — | — | >320, | 280? | <280 | — | >320, | >440, | >440 | — | 100 | 130? | >220 | >220 |

[1] Data by Myers and Johnson.
[2] Subculture medium.
[3] A chloramine-T product containing added alkali.

TABLE 2.—APPROXIMATE VALUES FOR EFFECTIVE CONCENTRATIONS OF DIVERSOL AND HTH-15 BY THE F.D.A. METHOD AND MODIFICATIONS THEREOF

| Inoculum | Subculture medium | Effective concentration (p.p.m. Av. Cl.) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Diversol | | | | | | | HTH-15 | | | | | | |
| Undiluted | Broth | 320? | <320, | 320, | <320, | 340, | 300, | 300 | 240? | 240? | 240? | 240? | <240, | 275, | 275 |
| Undiluted | Milk | >600, | 560, | 400, | 440, | 340? | 325, | 300 | 480, | 400, | 400, | 300? | 240, | 300, | 300 |
| Diluted 1/100 ($H_2O$) | Broth | 10? | < 10, | < 10, | < 5, | 5, | — | — | 5, | < 5, | 10, | < 5, | < 5, | — | — |
| Diluted 1/100 ($H_2O$) | Milk | 10? | 10, | 10, | 15, | 10, | — | — | 10, | < 5, | 10, | 10, | 5, | — | — |

was carried on Bacto nutrient agar, and 24-hour Bacto nutrient broth cultures were employed in the testing. One cc. of culture was added to 10 cc. of test solution and subcultures were incubated at 37° C. for 4 days. In all other respects, the directions given in U.S.D.A. Circular No. 198 were followed.

Since the wide spacing of the dilutions in the work of Myers and Johnson appeared to offer a likely explanation for the quite definite grouping indicated in their results, attempts were made to work with less scattered concentrations in the hope of obtaining more accurate data concerning the "effective concentration." From the start, however, great difficulty was experienced due to the prevalence of "skips" and "misses,"[1] and various attempts to overcome this drawback were unsuccessful. Even when duplicate subculture tubes were inoculated simultaneously by means of two loops fastened together, there was by no means satisfactory agreement. The substitution of litmus milk for broth as the subculture medium raised the "effective concentration" figures by about 40%, but skips were still frequently encountered. Approximate values for the "effective concentration" of the products tested are shown in Table 1, along with the values reported by Myers and Johnson for those which they also tested. Five additional runs were made comparing HTH–15 and Diversol, the data from which appear in Table 2. From these data it would appear that even with the F.D.A. method there is a somewhat greater difference between the germicidal potency of these two products than is indicated by the values given by Myers and Johnson.

Since the latter consider bottle washing tests to be the ultimate criterion in judging sterilizing agents, several runs were made following as closely as possible the technique described by them. A small Seitz bottle washing machine, with a single rotating jet, was employed to treat the bottles with hypochlorite; 10 cc. of sterile thiosulphate solution was used

TABLE 3.—RESULTS OF BOTTLE RINSING TESTS, APRIL 11, 1933

| | | Bottle number | | | | | Average per bottle |
|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | |
| | p.p.m. | Colonies per plate[1] | | | | | |
| Diversol | 21 | 4900 | 5400 | 6900 | 1150 | 3900 | 44,500 |
| | 32 | 1200 | 5850 | 1530 | 172 | — | 21,880 |
| | 45 | 5100 | 372 | 510 | 5400 | 10400 | 43,560 |
| | 62 | 95 | 38 | 4 | 2600 | 94 | 5,660 |
| | 77 | Spr. | 0 | 0 | 1 | 18 | 50 |
| | 95 | Spr. | 124 | 2 | 6 | 2 | 340 |
| HTH–15 | 21 | 2 | 1 | 19 | 0 | 3 | 50 |
| | 32 | 1 | 2 | 9 | 2 | — | 35 |
| | 39 | 2 | 3 | 4 | 3 | 10 | 44 |
| | 60 | 0 | 3 | 0 | 3 | 0 | 12 |
| | 77 | 0 | 0 | 1 | 65 | 0 | 132 |
| | 93 | 0 | 21 | 25 | 0 | 5 | 102 |
| Control | 0 | 27100 | 2100 | 5100 | 12100 | 6000 | 104,800 |

[1] One cc. of the 10 cc. sterile rinse plated on nutrient agar.

to rinse the bottles[2] after treatment with hypochlorite, and 1 cc. plated. Despite marked variations between bottles receiving identical treatment, the data obtained on a representative run (Table 3) indicate that HTH-15 is decidedly more effective as a bottle sterilizing rinse than is Diversol, although Myers and Johnson report effective concentrations of 38 and 29 p.p.m. respectively for these two products on bottle rinsing tests.

Discussing their reasons for selecting the F.D.A. method, the above authors mention, among other considerations, the following: "It appears to us that testing in the presence of considerable organic matter is desirable. Wherever very large numbers of bacteria are encountered, considerable organic matter is usually present. . . . As long as the amount of organic matter is kept constant as it is in the F.D.A. method, results on different products are comparable." One obvious objection to this claim is that organic chlorine compounds, being much less influenced by the presence of organic matter, tend to appear to better advantage in such a test than in actual plant practice as the results of Myers and Johnson plainly show. Furthermore, since the seeded test solution contains at the start around one hundred million cells of the test organism per cc. there seems to be no point to introducing further large quantities of organic matter from the broth culture. Fabian, Beavens, Bryan and Jensen (*6*), studying the influence of numbers of bacteria upon the chlorine content of sodium hypochlorite solutions at 50° C., found that a suspension of one hundred million cells per cc. reduced the strength from 46 to 22.6 p.p.m. in 30 minutes, a drop far greater than is found in plant practice where properly cleaned equipment is treated with sodium hypochlorite.[3] Studies on the influence of the excessive quantities of organic matter introduced in the F.D.A. method upon the available chlorine content of Diversol at 20° C. showed a decline from 200 to 144 p.p.m. in 15 minutes; where the culture was diluted 1/100 before seeding the test solution the loss was only 8 p.p.m. Furthermore, in view of the claim of Mallmann (*15*) and Fay (*7*) that *used* hypochlorite solutions containing traces of milk are of lower potency than are *fresh* solutions showing the same concentration of available chlorine by titration, it is probable that the loss in potency in the F.D.A. method is even greater than is indicated by the titration data. In an endeavour to check upon the influence of such large amounts of organic matter, parallel tests were run using the same broth culture diluted 1/100 with distilled water and also with broth. Table 4 contains data on the undiluted broth culture, Table 5 on the broth culture diluted 1/100 with water and Table 6 on the broth culture diluted 1/100 with sterile broth. Despite irregularities it is evident that the quantity of organic matter introduced in the broth culture has an influence upon the results far in excess of that exerted by the number of organisms themselves. Since so large a proportion of the chlorine present is thus used up in reacting with the excess organic matter, one might reasonably expect that with the F.D.A. method differences in sterilizing potency between hypochlorites of varying degrees of alkalinity would be minimized. As will be shown a little further on this is actually the case.

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[2] A bottle rinsed with 100 cc. of 80 p.p.m. Diversol, drained 1 minute, then rinsed with 10 cc. distilled water showed that 0.7 p.p.m. available chlorine was picked up by the rinse. To take care of this, the sterile rinse contained 0.01% of thiosulphate.

[3] This drop was practically the same as that encountered when 0.1% of ice cream mix was added to the sodium hypochlorite solution.

TABLE 4.—RESULTS OF TESTS AT 20° C. USING F.D.A. TECHNIQUE, FEB. 3. 1933 (*Staph. aureus* 67,000,000 PER CC.)

| Subculture medium | | Broth | | | Milk | | |
|---|---|---|---|---|---|---|---|
| Minutes exposure | | 5 | 10 | 15 | 5 | 10 | 15 |
| | p.p.m. Av. Cl. | | | | | | |
| B-K | 120 | + | + | − | + | + | + |
| | 140 | + | − | − | + | + | + |
| | 160 | − | − | − | + | + | + |
| | 180 | − | − | − | + | + | + |
| | 200 | − | − | − | + | + | + |
| HTH-15 | 320 | + | − | − | + | + | + |
| | 360 | − | − | − | + | + | − |
| | 400 | − | − | − | + | + | − |
| | 440 | + | − | − | + | + | − |
| | 480 | − | − | − | + | − | − |
| HTH-10 | 320 | + | − | − | + | + | + |
| | 360 | + | − | − | + | + | − |
| | 400 | − | − | − | + | − | − |
| | 440 | − | − | − | + | − | − |
| | 480 | − | − | − | − | − | − |
| Chlorosil | 280 | + | + | − | + | + | + |
| | 320 | + | − | − | + | + | + |
| | 360 | + | + | − | + | + | + |
| | 400 | − | − | − | + | − | − |
| | 440 | + | − | − | + | + | − |
| Neomoscan | 320 | + | + | − | + | + | + |
| | 360 | + | − | + | + | + | + |
| | 400 | + | − | − | + | + | + |
| | 440 | − | − | − | + | + | − |
| | 480 | − | − | − | − | − | − |
| Diversol[1] | 400 | ++ | −− | −− | ++ | ++ | ++ |
| | 440 | +− | +− | −− | ++ | ++ | ++ |
| | 480 | −− | −− | −− | ++ | ++ | −+ |
| | 520 | −+ | +− | −− | ++ | ++ | +− |
| | 560 | −+ | −− | −− | −+ | −+ | −− |
| Wyandotte Sterilizer | 280 | − | − | − | + | + | + |
| | 320 | − | − | − | + | + | + |
| | 360 | − | − | − | + | + | + |
| | 400 | − | − | − | + | + | + |
| | 440 | − | − | − | + | + | + |

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[1] The data here represent two sets of determinations made on this product during a single run.

Table 5.—Results of tests at 20° C. using F.D.A. technique, Feb. 3, 1933. (*Staph. aureus* 1,000,000 per cc. Original culture diluted 1:100 with $H_2O$

| Subculture medium | | Broth | | | Milk | | |
|---|---|---|---|---|---|---|---|
| Minutes exposure | | 5 | 10 | 15 | 5 | 10 | 15 |
| | p.p.m. Av. Cl. | | | | | | |
| B-K | 5 | – | – | – | – | + | – |
| | 10 | – | – | – | – | – | – |
| | 15 | – | – | – | – | – | – |
| | 20 | – | – | – | – | – | – |
| | 25 | – | – | – | – | – | – |
| HTH-15 | 10 | – | – | – | – | – | – |
| | 20 | – | – | – | – | – | – |
| | 30 | – | – | – | – | – | – |
| | 40 | – | – | – | – | – | – |
| | 50 | – | – | – | – | – | – |
| HTH-10 | 10 | – | – | + | + | – | – |
| | 20 | – | – | – | – | – | – |
| | 30 | – | – | – | – | – | – |
| | 40 | – | – | – | – | + | – |
| | 50 | – | – | – | – | – | – |
| Chlorosil | 20 | + | – | – | – | – | – |
| | 30 | – | – | – | – | – | – |
| | 40 | – | – | – | – | – | – |
| | 50 | – | – | – | – | – | – |
| | 60 | – | – | – | – | – | – |
| Diversol | 50 | – | – | – | – | – | – |
| | 65 | – | – | – | – | – | – |
| | 80 | – | – | – | – | + | – |
| | 95 | – | – | – | – | – | – |
| | 110 | – | – | – | – | – | – |
| Wyandotte Sterilizer | 100 | + | + | – | + | + | + |
| | 130 | + | – | – | + | + | + |
| | 160 | + | + | + | + | + | + |
| | 190 | + | – | – | + | + | + |
| | 220 | – | – | – | + | + | + |

Table 6.—Results of tests at 20° C. using F.D.A. technique, Feb. 3, 1933. (*Staph. aureus* 1,000,000 per cc.—original culture diluted 1 : 100 with broth)

| Subculture medium | | Broth | | | Milk | | |
|---|---|---|---|---|---|---|---|
| Minutes exposure | | 5 | 10 | 15 | 5 | 10 | 15 |
| | p.p.m. Av. Cl. | | | | | | |
| HTH-15 | 320 | – | + | + | – | + | + |
| | 360 | – | – | – | – | – | – |
| | 400 | – | – | – | + | – | – |
| | 440 | – | – | – | – | – | – |
| | 480 | – | – | – | – | – | – |
| Diversol | 400 | + | – | – | + | + | + |
| | 440 | – | – | – | – | – | – |
| | 480 | – | + | + | – | – | + |
| | 520 | + | – | – | + | + | + |
| | 560 | + | – | – | + | + | + |

### 2. LITMUS MILK TUBE METHOD

In order to avoid the excess of organic matter which the F.D.A. method employs, the test organism was next grown on agar slants, the growth suspended in sterile tap water and standardized so that the seeded test solution would contain ten million cells per cc. at the start. Subcultures were made in litmus milk tubes using first of all the double loop method. Later, one cubic centimeter portions of the seeded solution were subcultured in litmus milk in the hope of obtaining more regular results. Using this method, studies were then carried on in an endeavour to explain the findings reported by Fabian et al (*6*) the results of which are reported in detail in a separate paper (*13*). These workers stated that "the addition of alkalies to sodium hypochlorite increases its germicidal power," a conclusion at variance with that reached by a number of workers (*10*, *12*, *14*, *20*). This apparent contradiction was found to be due to the susceptibility of *Escherichia coli* (Fabian's test organism) to alkalies at 50° C., the killing being attributable to pH and temperature and *not to any increase in the germicidal potency of the hypochlorite* due to added alkali. At 20° C., added alkali depresses germicidal speed for this organism, and the same is true for *Staphylococcus aureus* at both temperatures.

### 3. BURRI SLANT METHOD

With the litmus milk tube method, "skips" and "misses" were still far too frequent for the method to be considered satisfactory. At this point Dr. R. P. Myers, who had been kept informed concerning our findings, agreed that the F.D.A. method was open to serious objection and that the use of a suspension containing less organic matter (such as was employed in the litmus milk tube method) would be more satisfactory. He also suggested (*18*) the adoption of the Burri slant method (*1*) for subculturing, since results by such a method would be roughly quantitative and errors resulting from the occasional carrying over of a resistant cell would be largely eliminated. The Burri slant method was therefore tested out along with the milk tube method on a series of eight sodium hypochlorite products and found to give a more definite end-point, with fewer "skips" and "misses" (Table 7). Later, when the modification of filtering the suspension of *Staph. aureus* through Whatman No. 41 paper before standardizing was adopted, few further irregularities were encountered, indicating that clumps of organisms which had not been broken up in shaking were the probable cause of "skips." The apparently greater resistance of the test organism with the milk tube method is believed to be due to the much heavier inoculum employed in subculturing—approximately three thousand times as great as with the Burri slant method.

### 4. INDICATOR METHOD FOR pH DETERMINATIONS

For some time the writer had been seeking a simple chemical test which would give information as to the germicidal potency of sodium hypochlorite solutions, and thus avoid the necessity for the more complicated bacteriological testing. Since all available data indicated the marked influence of alkalinity upon germicidal speed, it seemed that pH determinations might be used to judge of the relative potency of hypochlorite products. In order to study the correlation between germicidal potency and pH, it became necessary to make fairly accurate pH determinations.

TABLE 7.—COMPARATIVE RESULTS ON EIGHT SODIUM HYPOCHLORITE PRODUCTS BY THE BURRI SLANT AND MILK TUBE METHODS AT 20° C., SEPT. 28, 1933

| Concentration of Av. Cl. | 25 p.p.m. | | | | | | | | 25 p.p.m. | | | | | | | | 50 p.p.m. | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Method of subculturing | Burri slant | | | | | | | | Milk tube[1] | | | | | | | | Milk tube[1] | | | | | | | |
| Period of exposure (minutes) | ¼ | ½ | 1 | 2 | 5 | 10 | 20 | 30 | ¼ | ½ | 1 | 2 | 5 | 10 | 20 | 30 | ¼ | ½ | 1 | 2 | 5 | 10 | 20 | 30 |
| Sallex | 0<br>0 | 0<br>0 | 0<br>0 | 0<br>0 | 0<br>0 | | | | −<br>+ | −<br>− | −<br>− | −<br>− | −<br>− | −<br>− | −<br>− | −<br>− | −<br>− | −<br>− | −<br>− | −<br>− | −<br>− | −<br>− | −<br>− | −<br>− |
| B-K | 0<br>0 | 0<br>0 | 0<br>0 | 0<br>0 | 0<br>0 | | | | +<br>+ | −<br>− | −<br>− | −<br>− | −<br>− | −<br>− | −<br>− | −<br>− | +<br>+ | −<br>− | −<br>− | −<br>− | −<br>− | −<br>− | −<br>− | −<br>− |
| HTH | 0<br>0 | 0<br>0 | 0<br>0 | 0<br>0 | 0<br>0 | | | | −<br>+ | −<br>− | −<br>− | −<br>− | −<br>− | −<br>− | −<br>− | −<br>− | −<br>− | +<br>− | −<br>− | −<br>− | −<br>− | −<br>− | −<br>− | −<br>− |
| HTH-15 | +++<br>+++ | 56<br>90 | 0<br>0 | 0<br>0 | 0<br>0 | | | | +<br>+ | +<br>+ | +<br>+ | +<br>+ | −<br>− | −<br>− | −<br>+ | −<br>− | +<br>+ | +<br>+ | +<br>+ | +<br>+ | +<br>− | −<br>+ | ?<br>− | −<br>? |
| HTH-10 | +++<br>+++ | +++<br>++ | 0<br>0 | 0<br>0 | +++<br>0 | 0<br>0 | 0<br>0 | 0<br>0 | +<br>+ | +<br>+ | +<br>+ | +<br>+ | +<br>+ | +<br>− | −<br>− | −<br>− | +<br>+ | +<br>+ | +<br>+ | +<br>+ | −<br>+ | +<br>− | −<br>? | −<br>− |
| Chlorosil | +++<br>+++ | 107<br>12 | 0<br>0 | 0<br>0 | 0<br>0 | 0<br>0 | 0<br>0 | 0<br>0 | +<br>+ | +<br>+ | +<br>+ | +<br>+ | +<br>+ | +<br>+ | −<br>− | −<br>− | +<br>+ | +<br>+ | +<br>− | +<br>+ | ?<br>+ | −<br>− | +<br>− | +<br>− |
| Diversol (old) | ++++<br>++++ | ++++<br>++++ | ++++<br>++++ | +++<br>++ | 0<br>0 | 0<br>0 | 0<br>0 | 0<br>0 | +<br>+ | +<br>+ | +<br>+ | +<br>+ | +<br>+ | +<br>+ | +<br>+ | +<br>− | +<br>+ | +<br>+ | +<br>+ | +<br>+ | +<br>+ | ?<br>− | ?<br>− | ?<br>? |
| Diversol (new) | ++++<br>++++ | ++++<br>++++ | ++++<br>++++ | 1<br>11 | 0<br>0 | 0<br>0 | 0<br>0 | 0<br>0 | +<br>+ | +<br>+ | +<br>+ | +<br>+ | +<br>? | ?<br>+ | +<br>− | ?<br>? | +<br>+ | +<br>+ | +<br>+ | +<br>+ | ?<br>+ | +<br>+ | ?<br>? | ?<br>+ |

[1] One cc. of seeded NaOCl solution pipetted into 10 cc. sterile litmus milk.

N.B.—With the milk tubes, + = growth of test organism, − = no growth after 4 days at 37°.
With the Burri slants, the density of growth is indicated by the number of plus signs, except where the number of colonies was countable.

Earlier attempts at colorimetric determinations not having proven satisfactory, efforts were made to obtain data electrometrically.[4] However, satisfactory results could not be obtained with either hydrogen or quinhydrone electrodes, although both thiosulphate and peroxide were used to remove the available chlorine. Recalling that Cullen and Austin (*3*) mention the employment of powdered phenolphthalein as a rough end-point indicator of the degree of alkalinity of Dakin's solution (5000 ± p.p.m.) this was tried out on the 8 products shown in Table 7, and was *found to give gradations in colour in 50 and 100 p.p.m. solutions which closely paralleled their germicidal potency.* A 1% alcoholic solution of the same indicator will also furnish an indication of the alkalinity of the hypochlorite since the time required for decolorization increases with increasing alkalinity. Where a number of solutions are being compared, however, the powder method is more convenient, since the colour remains practically unchanged for several hours, and the solutions are more readily arranged in order of increasing alkalinity. Phenolphthalein is universally employed in dairy and other food plants as an indicator in titration, hence is readily available.

A convenient method of conducting the test is to weigh out accurately 10 mgm. lots of powdered phenolphthalein and place in each of a series of specially cleaned test tubes. The products to be tested are diluted to the concentration of chlorine desired for plant use (usually 50 or 100 p.p.m.) and 10 cc. quantities pipetted into correspondingly marked tubes. When all tubes have been so prepared, they are shaken vigorously four or five times and returned to the rack. After a minute or two the full colour has developed, and tubes may be arranged in order of increasing colour. The least alkaline products remain colourless or show only a faint magenta tint. As the alkalinity increases, the magenta colour deepens. With still higher alkalinity a reddish shade appears until with the most alkaline products (pH ca 11.5) the solution appears a deep ruby red, which Cullen and Austin attribute to the formation of red alkaline phenolphthalate. It should be noted that the degree of colour developed is considerably influenced by the amount of indicator powder added, hence care must be taken to add equal quantities to every tube in the series.

It was at first thought to be necessary to remove the available chlorine by adding the required amount of sodium thiosulphate solution, but it was later found that this step could be eliminated. In the test with the alcoholic solution of the indicator, if the available chlorine is removed, all solutions (except those of pH <9.6) assume the full magenta colour of the indicator and no differentiation is possible.

## 5. INDICATOR METHOD CHECKED AGAINST BURRI METHOD

In order to give the powdered phenolphthalein test a more thorough trial, twenty commercial sodium hypochlorite products were obtained; their relative germicidal potency was tested out by the Burri Slant method and compared with the order of alkalinity by the indicator test. In the first tests at 10 p.p.m. no differences could be detected between the nine least alkaline products, so further tests were conducted at reduced chlorine concentrations. Data from one such run at 2 p.p.m. in which determinations were made in duplicate are presented in Table 8. In this table the products are arranged in approximately the order of increasing alkalinity *as determined by the indicator test at 100 p.p.m.*[5] to exhibit the correlation between alkalinity and germicidal speed. While there is no question as to the general trend, it is obvious that certain products, notably Pure-A-Fac and Antiformin, show greater germicidal potency than would be expected from the alkalinity rating. These anomalous results suggested that differences in buffer capacity of the solutions might be responsible, since the alkalinity was being determined on 100 p.p.m. while the germicidal tests were on 2 p.p.m. Accordingly, alkalinity tests were conducted on the 2 p.p.m. solutions, and the approximate ranking as shown in the last column of Table 8 supports the above hypothesis. More exact data were secured some weeks later by means of the glass electrode, and the pH values of these solutions at 100 and at 2 p.p.m. are given in Table 9. From these data it is evident that a method of germicidal testing which makes use of a very low concentration of available chlorine[6] may, in the case of poorly buffered products such as Pure-A-Fac and Antiformin, indicate a comparative efficiency much greater than will be found where these products are employed at concentrations of 50 p.p.m. or higher.

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[4] Thanks are due to Messrs. C. H. Robinson and J. T. Jansen of the Division of Chemistry, Central Experimental Farm, for assistance in this phase of the work.

TABLE 8.—GERMICIDAL POTENCY OF NINETEEN SODIUM HYPOCHLORITE SOLUTIONS AT 2 P.P.M. AV. CL. AS MEASURED BY THE BURRI SLANT TECHNIQUE AT 20° C., JAN. 4, 1934

| | Ranking in alkalinity by indicator test at *100* p.p.m. | Period of exposure (minutes) | | | | | | | | | | | | | | Ranking in alkalinity by indicator test at *2* p.p.m. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | ¼ | | ½ | | 1 | | 2 | | 5 | | 10 | | 20 | | |
| B–K solution | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | | | | | 1 |
| Merclor | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | | | | | 1 |
| HTH | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | | | | | 1 |
| Sallex | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | | | | | 1 |
| Germo Kil | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | | | | | 1 |
| B–K Powder | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | | | | | 1 |
| Washine | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | | | | | 1 |
| Dalglish | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | | | | | 1 |
| Perchloron | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | | | | | 1 |
| Jerdis | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | | | | | 1 |
| HTH–10 B | 5 | + | 83 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | | | 2 |
| Chlorosil | 6 | + | + | + | + | + | + | 8 | 18 | 0 | 0 | | | | | 4 |
| HTH–15 | 6 | + | + | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | | | 2 |
| HTH–10 A | 6 | + | + | + | + | 4 | 0 | 0 | 0 | 0 | 0 | | | | | 3 |
| Pure-A-Fac | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | | | 2 |
| Antiformin | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | | | 1 |
| Neomoscan | 8 | + | + | + | + | + | + | + | + | 0 | 5 | 0 | 0 | 0 | 0 | 6 |
| Diversol (new) | 8 | + | + | + | + | + | + | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 |
| Diversol (old) | 8 | + | + | + | + | + | + | + | + | 0 | 0 | 0 | 0 | 0 | 0 | 6 |

+ = too numerous to count.

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[5] This value was selected when developing the test as being the minimum strength generally recommended for rinsing or flushing out dairy utensils and equipment. At concentrations as low as 2 p.p.m. it is more difficult to obtain colour differences between solutions of mild alkalinity.

[6] Such a method also introduces difficulties due to the rapidity with which the available chlorine is dissipated even at room temperature.

TABLE 9.—INFLUENCE OF DILUTION UPON pH VALUES OF VARIOUS SODIUM HYPOCHLORITE SOLUTIONS, MARCH 16, 1934

| Product | pH at 100 p.p.m. Av. Cl. | pH at 2 p.p.m. Av. Cl. | Drop in pH |
|---|---|---|---|
| B-K Solution | 9.2 | 6 6 | 2.6 |
| Merclor | 9.5 | 6.2 | 3.3 |
| Germo-Kil | 9.6 | 6.3 | 3.3 |
| Sallex | 9.7 | 6.3 | 3.4 |
| HTH | 9.9 | 6.5 | 3.4 |
| B-K Powder | 10.2 | 6.7 | 3.5 |
| Perchloron | 10.2 | 6.3 | 3.9 |
| Dalglish | 10.3 | 6.8 | 3.5 |
| Washine | 10.4 | 6 8 | 3.6 |
| HTH-10 B | 10.5 | 9.1 | 1.4 |
| Jerdis | 10 7 | 6.9 | 3.8 |
| Klor-Rin | 11.0 | 9.1 | 1.9 |
| Chlorosil | 11 0 | 9 6 | 1.4 |
| HTH-15 | 11.2 | 8.9 | 2 3 |
| HTH-10 A | 11.2 | 9 4 | 1.8 |
| Antiformin | 11 4 | 8.4 | 3.0 |
| Pure-A-Fac | 11.6 | 8 6 | 3.0 |
| Diversol (New) | 11.6 | 9 6 | 2.0 |
| Neomoscan | 11.7 | 9.9 | 1.8 |
| Diversol (Old) | 11.9 | 10.0 | 1.9 |

## 6. PLATING METHOD

Since the amount of seeded solution carried over to the Burri slant is so small (ca 0.0003 cc.) it was hoped that the subculturing of a larger amount would enable the detection of differences in germicidal speed among the more active hypochlorites. Accordingly, the technique for the Burri method was modified to allow the pipetting of 1 cc. portions of seeded test solution into sterile petri dishes after definite periods of exposure, nutrient agar being poured in immediately to stop the action of the chlorine. The data appearing in Table 10 however indicate that with the more active hypochlorites no difference in speed can be detected by this method

TABLE 10.—GERMICIDAL POTENCY OF TWELVE HYPOCHLORITE SOLUTIONS AT 2 P.P.M. AV. CL. AS MEASURED BY THE PLATING METHOD AT 20° C., JAN. 31, 1934

| — | Period of exposure (min.) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | ¼ | | ½ | | 1 | | 2 | |
| Germo Kil | 420 | 242 | 121 | 102 | 62 | 45 | 24 | 18 |
| Sallex | 233 | Spr. | 133 | 141 | 60 | 70 | 43 | 39 |
| B-K solution | 244 | 296 | 118 | 139 | 72 | 62 | 23 | 33 |
| B-K Powder | 244 | 280 | 128 | 146 | 56 | 58 | 29 | 39 |
| HTH | 342 | 284 | 142 | 197 | 100 | 80 | 66 | 45 |
| Perchloron | 290 | 314 | 126 | 156 | 76 | 68 | 30 | 33 |
| Dalglish | 328 | 448 | 165 | 207 | 76 | 76 | 49 | 45 |
| Jerdis | 310 | 290 | 128 | 200 | 71 | 80 | Spr. | 40 |
| Merclor | 298 | 312 | 141 | 150 | 56 | 79 | 33 | 36 |
| Washine | 246 | 490 | 147 | 206 | 50 | 69 | 40 | 43 |
| Antiformin | 1200 | 1086 | 200 | 248 | 70 | 54 | 19 | 161 |
| HTH-15 | +++[1] | +++ | + | + | 133 | 196 | 23 | 62 |

[1] Plus signs indicate density of colonies where plates were too crowded for counting.

although the slightly slower killing by Antiformin did not show up under the Burri technique. The lag in killing with Antiformin and HTH-15 is evidently associated with higher alkalinity as the pH values obtained subsequently with the glass electrode indicate (Table 9).

It is interesting to observe that after two minutes exposure there is little difference between the two more alkaline solutions and the remaining ten. Apparently a small number of resistant cells are able to survive even the more active hypochlorites for this length of time. With the Burri technique the amount subcultured is so small that one of these resistant cells is not often included. Furthermore, the initiation of growth by a single cell is generally recognized as being much more difficult, so the absence of growth on the Burri slants is not surprising.

The results recorded in Table 10 indicate that the more active hypochlorites at 2 p.p.m. destroyed approximately 99 997% of the test organisms within fifteen seconds, and that no significant differences in speed could be detected. Since the plating method is more expensive than the Burri method as well as being open to the objections recorded in the last paragraph of Section 5, there seemed to be no advantage in employing it more extensively for routine testing.

## 7. GLASS SLIDE METHOD

Since all of the biological testing methods so far described are open to serious objection, an attempt was made at this point to develop one which would prove more satisfactory. In the sterilization of dairy equipment and utensils the problem is to destroy or remove organisms present on a surface in a thin film containing more or less organic matter (milk solids). This is obviously a more difficult task than the destruction of the test organisms when freely suspended in the sterilizing solutions as in the usual methods of disinfectant testing. Furthermore, the greater detergent properties of the more alkaline hypochlorites might be expected to compensate to some extent for the depressive action of the alkalinity upon germicidal speed, a feature which the usual methods do not take into account. Finally, it was considered desirable that the method be readily applicable to solutions at concentrations similar to those commonly employed in plant practice, in order that anomalies such as were encountered with the Burri slant method might be avoided.

The first trials were made with the test organisms present in a film of gelatin covering the lower half of a metal strip, which was then immersed in the hypochlorite solution for the required period, transferred to a sterile petri dish and nutrient agar poured over the strip to stop the action of the chlorine on the surviving bacteria. Gentle agitation of the strip while in the hypochlorite was found to reduce materially the number of organisms remaining on the slide. Since in plant practice the flushing or rinsing solution is moving over the surface to be sterilized, the agitation of the metal strips was adopted as a feature of this test. It was found difficult to get the film of gelatin to adhere uniformly to the surface of the metal strip, so glass microscopic slides were substituted. These, where carefully cleaned, gave no trouble in this respect, and in addition had the advantage of transparency. After several trials, skim milk, diluted to one-tenth, was substituted for gelatin as being more representative of the organic matter encountered on dairy equipment and utensils.

In the tests employing this method, a suspension of *Staph. aureus* No. 209 was prepared from a 24-hour growth on Bacto nutrient agar, filtered through a Whatman No. 41 paper, and standardized to contain approximately 250,000,000 cells per cc. One cubic centimeter was then mixed with 60 cc. of 1/10 dilution of sterile skim milk in a jelly jar with metal cover. (This quantity is sufficient to half immerse a 1″ × 3″ microscopic slide). A slide was dipped into the milk suspension, removed, the excess liquid allowed to drain off and the slide placed on end in a specially constructed draining pail, where several layers of filter paper on the perforated false bottom promoted further drainage of the excess of milk suspension. Sufficient slides to make the necessary tests on a given solution were prepared in succession and placed in the draining pail. After the last slide was treated the first was removed, immersed in 100 cc. of the hypochlorite solution in a sterile 100 cc. beaker and gently agitated during the exposure period. At the end of this period, the slide was quickly transferred to a petri dish and the plate poured immediately with nutrient agar. After incubation at 37° C. for forty-eight hours the number of colonies was recorded. Control slides were plated direct from the draining can and an estimate made of the number of colonies present. (A later modification consisted of preparing a milk suspension with 1 cc. of a 1/100 dilution of the standardized suspension of *Staph. aureus*. Control plates poured from slides dipped into this suspension were much more easily counted. The average number was then multiplied by 100 to compensate for the dilution of the suspension). This number was then used to calculate the number of colonies allowable at the end-point, which was usually the shortest period in which 99.75% of the organisms had been killed or removed. All equipment and supplies used in the test were carefully sterilized before use and care was taken to avoid contamination during the testing. All tests were conducted at 20° C.; at this temperature the number of organisms in the milk suspension increased gradually (approximately 50% in two hours) but this had no detectable influence upon the results. (Jensen and Jensen (*9*) in their recent description of a technique in which a loopful of a suspension of *Staph. aureus* is dried upon a cover slip and then immersed in the disinfectant, have varied the number of organisms in their suspension eight-fold without detecting any difference in results). On the other hand, an attempt to prevent growth by holding the milk suspension in ice water resulted in a tremendous increase in resistance within a similar period.

## 8. TESTS ON SODIUM HYPOCHLORITE PRODUCTS USING GLASS SLIDE METHOD

After a number of preliminary tests, the glass slide method was tested out upon a series of 13 hypochlorites of varying alkalinity at a concentration of 100 p.p.m. Av. Cl. The results of one such run are presented in Table 11 where the end point has been calculated[7] as the destruction of 99.75% of the estimated number present on the control slides. In this particular experiment the counts appearing in the left-hand column under each exposure period were obtained in one run, and those in the right-hand column in a later run on the same day using a fresh suspension of the test organism. In one run the solutions were tested in the order shown in the table, and in the other, in the reverse order. The product Klor-Rin

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[7] The average count of the two plates was taken in calculating the end point for each product.

TABLE 11.—GERMICIDAL POTENCY OF SODIUM HYPOCHLORITE SOLUTIONS AT 100 P.P.M. AV. CL. AS MEASURED BY GLASS SLIDE TECHNIQUE, AT 20° C., MARCH 1, 1934

| Product | pH | Period of exposure (min.) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | ⅛ | | ¼ | | ½ | | 1 | | 2 | | 5 | |
| B–K solution | 8.96 | 3 | 1 | 0 | 0 | 0 | 0 | | | | | | |
| HTH | 9.8 | 0 | 0 | 0 | 0 | 0 | 0 | | | | | | |
| Jerdis | 10.45 | 74 | 11 | 34 | 0 | 63 | 0 | | | | | | |
| HTH–10 B | 10 5 | 330 | + | 2 | 3 | 1 | 0 | | | | | | |
| Klor-Rin | 10 75 | | | + | + | 37 | 4 | 0 | 5 | 2 | 0 | | |
| Klor-Rin | 10.75 | | | 608 | 247 | 8 | 1 | 3 | 0 | 2 | 0 | | |
| Chlorosil | 10.92 | | | + | + | 2 | 1 | 0 | 3 | | | | |
| HTH–10 A | 11 0 | | | + | + | 87 | 315 | 0 | 0 | 0 | 0 | | |
| HTH–15 | 11.2 | | | + | + | 522 | 311 | 7 | 0 | 0 | 1 | | |
| Antiformin | 11 35 | | | + | + | 205 | 660 | 5 | 14 | 1 | 0 | | |
| Pure-A-Fac | 11 35 | | | + | + | 800 | 363 | 119 | 1 | 0 | 0 | | |
| Neomoscan | 11.52 | | | + | + | 226 | 804 | 24 | 110 | 0 | 3 | 0 | 0 |
| Diversol (new) | 11.52 | | | + | + | 119 | 800 | 11 | 42 | 0 | 0 | | |
| Diversol (old) | 11 85 | | | 295 | + | 199 | 186 | 60 | 14 | 1 | 1 | 4 | 0 |

+ = >500 colonies.
Control slides estimated at 35,000.
∴ a count of <88 = 99.75 per cent reduction.

was tested at the beginning and end of each run, in order to check on possible variations in the resistance of the test organism in the diluted skim milk during the approximately two hour period of each run. As will be observed from Table 11, no significant change in resistance is evident, and this point has been substantiated by the results of several other tests.

Throughout these studies it is evident that germicidal speed is retarded with increasing pH. The data recorded in Table 11 however suggest that with the glass slide technique there may be some factor operating at pH >11.0 whereby the influence of further increase in alkalinity is at least partially compensated for. It seemed probable that this factor might be detergent action, since Diversol (old) solution at 100 p.p.m. chlorine contains approximately 0.33% of tri-sodium phosphate. Tests were made upon several occasions in which sterile solutions of tri-sodium phosphate and sodium carbonate of appropriate concentrations were compared with distilled water in their ability to remove the test organisms and their accompanying milk film at 20° C. but no significant difference was observed. Further tests using 100 p.p.m. solutions of old Diversol, Chlorosil and HTH to which sufficient sterile sodium thiosulphate had been added to react with the available chlorine again showed no advantage over distilled water. Since no superior detergent action could be shown even with the most alkaline product, a series of eleven hypochlorites was tested out with shorter intervals between the periods of exposure, in hopes of detecting differences which might have been missed in the work reported in Table 11.

The results from this series are given in Table 12, the products being arranged in order of increasing pH as determined with the glass electrode on 100 p.p.m. solutions. Here, with the exposure periods more closely spaced, it will be observed that there is still some slowing down in germicidal speed above pH 11.0. Along with the eleven hypochlorite products are shown results from two other chlorine disinfectants. The first of these,

TABLE 12.—GERMICIDAL POTENCY OF CHLORINE SOLUTIONS AT 100 P.P.M. AV. CL. AS MEASURED BY GLASS SLIDE TECHNIQUE AT 20° C., MAY 3, 1934

| | pH | Period of exposure (seconds) | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 5 | | 10 | | 15 | | 20 | | 30 | | 40 | | 50 | | 60 | | 75 | | 90 | | 120 | | 300 |
| B-K | 9.2 | **14** | 4 | 0 | 0 | 0 | 0 | | | | | | | | | | | | | | | | | | |
| Merclor | 9 8 | **1** | 0 | 1 | 0 | 1 | 0 | | | | | | | | | | | | | | | | | | |
| HTH | 10.1 | **2** | 1 | 0 | 0 | 1 | 0 | | | | | | | | | | | | | | | | | | |
| HTH-10 B | 10 6 | | | | 9 | | 2 | 1 | 0 | 0 | 7 | 3 | 0 | 1 | 0 | | | | | | | | | | |
| Chlorosil | 10.9 | | | | | | | | 215 | | **53** | **10** | 7 | 0 | 1 | 0 | 2 | 0 | 0 | | | | | | |
| HTH-15 | 11.4 | | | | | | | | | | + | | + | + | 412 | 290 | **38** | **37** | 0 | 0 | | | | | |
| Antiformin | 11.52 | | | | | | | | | | + | | + | | + | + | 142 | 36 | **1** | **4** | 1 | | 0 | | |
| Diversol (new) | 11 56 | | | | | | | | | | + | | + | | + | | + | + | **31** | | 6 | | 0 | | |
| Pure-A-Fac | 11.65 | | | | | | | | | | + | | + | | + | + | + | + | **72** | **9** | 2 | | 1 | | |
| Neomoscan | 11 7 | | | | | | | | | | | | + | | + | | + | + | 270 | 121 | **8** | **4** | 1 | 0 | |
| Diversol (old) | 11.95 | | | | | | | | | | | | + | | + | | + | + | + | + | **41** | **18** | 0 | 0 | |
| HC | 10 5 | | | | | | | | + | | + | + | + | + | + | + | + | + | + | + | | | | | |
| Azochloramid | 6 0 | | | | | | + | + | | | + | + | | | + | + | + | + | | | + | + | + | + | 460 |
| (sat'd. aqueous) | | | | | | | | | | | | | | | | | | | | | | | | | |

HC, was assumed to be a hypochlorite (being far more alkaline than any chloramine-T compound encountered so far), and exposure periods were chosen accordingly. However, subsequent testing with the O-tolidene method has shown the very slow development of colour characteristic of the chloramine-T compounds. Azochloramid, a recently developed product (*24*) said to be extremely stable in the presence of organic matter, was tested as a saturated aqueous solution, but appears to be too slow acting for the sterilization of metal surfaces.

In view of the fact that hypochlorite solutions showing such tremendous differences in sterilizing speed are being employed in dairy sanitation, it appeared to be of interest to determine how much stronger solutions of a few of the more alkaline products would need to be in order to kill as rapidly as a product such as HTH. Data obtained with the glass slide technique are presented in Table 13, and indicate that where the exposure period must be brief, much stronger solutions of the more alkaline hypochlorites are necessary to obtain the same degree of destruction.

TABLE 13.—EQUIVALENT CONCENTRATIONS OF FOUR SODIUM HYPOCHLORITE PRODUCTS AS JUDGED BY GLASS SLIDE TECHNIQUE AT 20° C.

| | p.p.m. Av. Cl. | Period of exposure in seconds | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 5 | | 10 | | 15 | | 20 | | 40 | |
| HTH *(a)* | 10 | **26** | **5** | 1 | 4 | 6 | | 1 | | | |
| *(b)* | 10 | **81** | **43** | 5 | 100 | | | 0 | | 1 | |
| HTH-10 B *(b)* | 100 | ++ | | 252 | | | | **3** | **0** | 1 | |
| | 150 | ++ | ++ | **5** | **1** | | | 0 | | 0 | |
| | 200 | **0** | **0** | 0 | 0 | | | 0 | | 0 | |
| HTH-15 *(a)* | 200 | ++ | | + | 430 | **12** | **8** | 11 | 10 | | |
| | 300 | **42** | | 8 | 11 | 5 | 3 | 0 | | | |
| | 400 | **60** | **52** | 1 | 3 | 0 | 1 | 0 | | | |
| | 500 | **12** | **2** | 1 | 2 | 0 | 0 | 0 | | | |
| Diversol (old) *(b)* | 100 | + | | 363 | | | | 233 | 12 | **24** | **3** |
| | 200 | Spr. | | 109 | 19 | | | **5** | **71** | 0 | |
| | 300 | **55** | **5** | 25 | 48 | | | 0 | 0 | 0 | |
| | 400 | Spr. | **64** | 6 | 2 | | | 0 | | 0 | |

N.B —*(a)* Test of March 27, 1934.
*(b)* Test of April 6, 1934.

The counts in black type mark the shortest exposure period where the average of two plates indicates 99 75% destruction. Control plates estimated at 30,000.

## 9. THE EFFECT OF ADDING SODIUM THIOSULPHATE TO NUTRIENT AGAR

In the studies reported in this and previous papers it has been assumed that the organic matter in nutrient agar would react with and stop further action of the chlorine in the portion of the test solution transferred for subculturing. However, at this stage (May, 1934) the correctness of this assumption was tested by making parallel sets of determinations with the glass slide method on representative products, pouring one set with nutrient agar in the usual manner and the other with nutrient agar to which 0.1% sodium thiosulphate had been added just before pouring the plates. The data obtained (Table 14) indicate that some further killing or inhibition of growth does take place after the plate has been poured with nutrient agar. However, there is no reason to believe that the ranking in order of relative potency of a series of hypochlorite products would be disturbed by the employment of thiosulphate. Nevertheless for future studies it was decided to dip the glass slides in a sterile 1% solution of thiosulphate immediately after removal from the hypochlorite solution and thus make certain that the action of the chlorine is checked instantaneously.

TABLE 14.—EFFECT OF ADDING SODIUM THIOSULPHATE TO NUTRIENT AGAR UPON COUNTS OBTAINED WITH THE GLASS SLIDE METHOD ON HYPOCHLORITE SOLUTIONS OF 100 P.P.M. AV. CL. AT 20° C., MAY 17, 1934

| | Period of exposure (seconds) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 5 | 10 | 20 | 30 | 40 | 50 | 60 | 75 | 90 | 120 | 150 |
| HTH *(a)* | **10**<br>**71** | 1<br>1 | 0<br>1 | | | | | | | | | |
| HTH *(b)* | 83<br>+ | **0**<br>**9** | 0<br>0 | | | | | | | | | |
| HTH–15 *(a)* | | | | | +<br>+ | 667<br>195[1] | **43**<br>**38** | 1<br>8 | 10<br>1 | | | |
| HTH–15 *(b)* | | | | | +<br>+ | +<br>84 | 363<br>472 | 141<br>158 | **10**<br>**2** | 3<br>2 | | |
| HTH–15 *(c)* | | | | | +<br>+ | +<br>+ | 383<br>? | 99<br>43 | **0**<br>**1** | | | |
| Diversol (old) *(a)* | | | | | | | 380[1]<br>339[1] | 481<br>155[1] | 238<br>100[1] | 154<br>45 | **28**<br>**20** | |
| Diversol (old) *(b)* | | | | | | | | +<br>+ | +<br>+ | +<br>+ | 213<br>97 | **5**<br>**1** |

*(a)* = nutrient agar;
*(b)* = nutrient agar + 0 1% thio, fresh;
*(c)* = same as *(b)*, but several weeks old, and had been autoclaved 4-5 times.
+ = >500 colonies;
[1] = count lowered by spreaders.
<56 per slide = 99.75 per cent reduction.

## 10. THE EFFECT OF DILUTION UPON THE GERMICIDAL POTENCY OF HYPOCHLORITE SOLUTIONS

In all published data which the writer has seen,[8] increasing dilution of the hypochlorite solution has resulted in a decline in germicidal speed. However, the data obtained with the Burri slant method between September, 1933, and January, 1934, indicated no significant difference between the first tests using 25 p.p.m. and later ones using 10 and 2 p.p.m. available chlorine. At the time this was attributed to a decline in the resistance of the test organism, although this point was not investigated. However, glass electrode studies made some weeks later on the effect of dilution upon the pH of a number of hypochlorites showed that the curve came down very sharply in this region (the distilled water, autoclaved in

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[8] An exception occurs in the paper of Ram Ayyer (*21*) where a concentration of 20 p.p.m. was more effective than 100 or 200 p.p.m. in the destruction of spores of *B. subtilis*. The explanation offered, that nascent chlorine is liberated slowly on dilution, scarcely appears to be adequate.

2 liter Pyrex flasks, used in dilution usually had a pH value of between 5.3 and 6.0) suggesting that this marked change in pH might exert some influence.

In order to determine more definitely just what effect dilution had upon germicidal potency, HTH–15 solution (selected as being intermediate in alkalinity and buffer capacity) was tested out with *(a)* the plating method and *(b)* the glass slide method on dilutions made up to contain 25, 10, 2 and 1 p.p.m. as prepared. In order to control more accurately the period of exposure to the test solution in the plating method, 1 cc. of sterile 1% sodium thiosulphate solution was placed in each petri dish to check further action of the chlorine when 1 cc. of seeded test solution was pipetted into the petri dish. With the glass slide method, the treated slides were dipped into sterile 1% thiosulphate solution as described in Section 9. From the data in Table 15 it will be observed that there is no great difference between 25 and 10 p.p.m. but that 2 p.p.m. is distinctly more active than 10 p.p.m. The results with 1 p.p.m. are rather peculiar. With the plating method it would seem that the addition of over nine million cells per cc. reduced the amount of available chlorine to the point where it was insufficient to cause any significant destruction, since plates poured after two minutes showed as heavy growth as those poured after thirty seconds. With the glass slide method, 1 p.p.m. appears to be almost as effective as 2 p.p.m. on the first few slides but as the organic matter content of the test solution increases (due to the washing off of the milk film from the slides), its potency declines, and thus the later slides show more surviving organisms despite the longer exposure period.

The explanation of these anomalous results is believed to lie in the effect of pH upon the proportion of the total "available chlorine" existing in the form of hypochlorous acid, it being generally conceded that the latter is the germicidally active component. Determinations were therefore made of the pH values of HTH–15 solution at concentrations between 25 and 1 p.p.m. available chlorine. From these data the concentration of hypochlorous acid was calculated for each point by the Henderson-Hasselbalch equation, pH = pKa + log (salt)/(acid), employing Sand's (*24*) value (recently confirmed by glass electrode electrometric titration by Davidson (*4*)) of $3.7 \times 10^{-8}$ for Ka. Both sets of data are presented graphically in Figure 1, where we observe that the minimum concentration of hypochlorous acid occurs with this particular product in the neighbourhood of 20 p.p.m., rising sharply as the pH of the solution approaches that of the distilled water (pH 5.5)

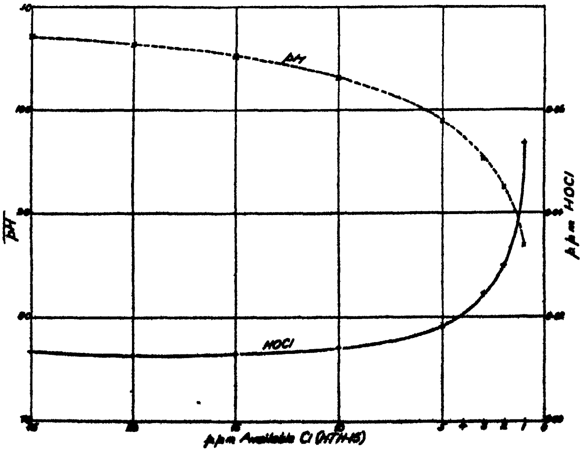

FIGURE 1. pH and HOCl concentration of HTH-15 solutions containing varying amounts of available chlorine.

TABLE 15.—COMPARATIVE GERMICIDAL EFFICIENCY OF VARIOUS CONCENTRATIONS OF HTH-15 AT 20° C. (PLATING AND GLASS SLIDE METHODS, MAY 23, 1934)

|  | p.p.m. | pH | Period of exposure (seconds) |  |  |  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 105 | 120 |
| Plating 1 cc. *(a)* | 25 | 10.70 | ++++<br>++++ | +++<br>+++ | ++<br>++ | 2500 est.<br>514 | 84<br>3 | 21<br>0 | 9<br>2 | 1<br>0 |  |  |
|  | 10 | 10.28 | ++++<br>++++ | ++<br>++ | 350*<br>+ | 2<br>+ | 3<br>26 | 3<br>44 | 3<br>8 | 90<br>1350 est. | 4<br>+ |  |
|  | 2 | 9.26 |  | 17<br>187 | 6<br>43 | 4<br>18 | 4<br>13 | 1<br>36 | 3<br>336 | 2<br>21 | 2<br>13 | 0<br>3 |
|  | 1 | 8 70 |  | ++++<br>++++ | ++++<br>++++ | ++++<br>++++ | ++++<br>++++ | ++++<br>++++ | ++++<br>++++ | ++++<br>++++ | ++++<br>++++ | ++++<br>++++ |
| Glass Slide *(b)* | 25 | 10.70 |  | +<br>+ | +<br>+ | +<br>+ | +<br>513* | 527<br>7* | 207<br>169 | 74<br>55 |  |  |
|  | 10 | 10.28 |  | +<br>+ | +<br>+ | +<br>+ | +<br>+ | +<br>? | 236<br>294 | 66<br>73 |  |  |
|  | 2 | 9.26 |  | 593<br>793 | 70<br>18 | 3<br>122 | 9<br>118 | 0*<br>0* | 0*<br>6 | 8<br>0 |  |  |
|  | 1 | 8.70 |  | +<br>93 | +<br>81 | 103<br>61* | +<br>110 | +<br>165 | +<br>+ | +<br>+ |  |  |

N.B.—*(a)* 9,050,000 per cc. in test solution for plating method; 99 999 per cent destruction leaves 91 colonies per cc. plated.
Plus signs indicate density of growth.
*(b)* Glass slides averaged 25,000 per slide; 99.75 per cent destruction leaves 64 colonies per slide.
Plus sign indicates >500 colonies.

*Count lowered by spreaders.

used in preparing the dilutions. However, under practical conditions the greater instability of the solution as the proportion of hypochlorous acid increases, and the loss of potency due to reaction with traces of organic matter make it inadvisable to employ too dilute solutions. It is hoped that further studies upon this phase of chlorine sterilization may be undertaken in the near future.

## DISCUSSION

The results presented in this paper indicate certain difficulties encountered in evaluating the germicidal potency of a series of hypochlorite solutions. This potency at 20° is clearly shown to be dependent upon both the concentration of available chlorine and the pH of the solution, or more specifically, upon the concentration of hypochlorous acid which is dependent upon these two. But although the chlorine concentration changes uniformly upon dilution this is not true of the pH value, because of differences in buffer capacity between various hypochlorite products[9] and because of the increasing rate of change of pH as the chlorine concentration approaches zero. Consequently the potency indicated by one technique may, in the case of certain products, be decidedly different from that by another, where a much greater or lesser dilution is employed. Furthermore, the introduction of an excess of organic matter, as in the F.D.A. method, unduly favours the organic chlorine compounds, while differences in speed of action between mildly and strongly alkaline hypochlorite solutions are greatly minimized. It might be mentioned at this point that the Food and Drug Administration of the United States Department of Agriculture hold the following view (*16*): "Neither the F.D.A. method of determining phenol coefficients nor any of the other coefficient methods with which we are familiar are suited to the examination of chlorine disinfectants." Instead, attention is chiefly directed to the content of available chlorine, although the depressive influence of excessive amounts of alkali is also taken into consideration in connection with the dilution recommended by the manufacturer.

At a given concentration of available chlorine, germicidal potency appears to vary directly with the decrease in hydroxyl ion concentration. Therefore, a simple method such as the indicator test described in this paper enables ready differentiation between hypochlorites of varying degrees of potency. Furthermore, this test may be applied on hypochlorite solutions of the exact concentration at which they are to be employed in plant practice, an advantage not enjoyed with most biological methods of disinfectant testing.

Where it is considered desirable to use a biological testing method, the glass slide method offers certain advantages over the methods generally employed. It approximates more nearly the conditions under which bacteria have to be destroyed (or removed) in plant practice in that the latter are present in a moist film of diluted milk upon a surface rather than being freely suspended in the disinfectant solution. It also allows any superiority in detergent action to exert an influence, a factor which may be of importance under practical conditions and at higher temperatures

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Because of this it is not feasible to employ a fixed period of exposure as recently suggested by Jensen (*9*) for phenol coefficient studies.

and which receives no consideration in the usual testing methods.[10] Furthermore, tests may be conducted on solutions of the strength used in the plant, thus avoiding erroneous impressions of the effectiveness of certain products as were obtained with the Burri slant method. Lastly, the method possesses great flexibility in that the concentration of the test organism and of chlorine, and the period of exposure to the latter, may be varied within wide limits. In no other method has it been possible to employ exposure periods of less than 8–10 seconds (*28*) while with the glass slide method an exposure of 1 second presents no difficulties.

It has been shown by Dole (*5*) and others that where the pH of a solution containing sodium ion is above 9.5 the observed E.M.F. with the glass electrode is no longer a linear function of the pH, and that the deviation increases with the concentration of sodium ion present in the solution. In preparing the calibration curves for the glass electrode in the present studies, buffer solutions of M/20 concentration were employed to obtain two points beyond pH 9.5, in addition to four other solutions between pH 3.97 and 9.15. Since the hypochlorite solutions tested contained a variety of sodium salts (carbonate, bicarbonate, phosphate, silicate, hydroxide), it is probable that the concentration of sodium ions in solutions above pH 9.5 would show some variation. It is unlikely, however, that such variations would be sufficiently marked to introduce any significant error because of the degree of dilution (100 p.p.m. available chlorine is 0.00283 N) of the solutions employed. While no claims are made for extreme accuracy in the pH values obtained, it is felt that they furnish a fairly satisfactory indication of the degree of alkalinity of the various products.

In the testing of certain products it was observed that the solution became more acid upon standing in a stoppered flask. In one instance this change occurred so rapidly that the pH had fallen from 10.62 to 10.12 within an hour. This doubtless explains certain slight discrepancies between the results obtained on some of the less alkaline products by the indicator test (Table 8) and by the glass electrode (Table 9). In the former, all solutions were prepared together so that all would enjoy approximately the same period of contact with the phenolphthalein powder before being arranged in order of increasing colour. In the glass electrode studies, each solution was prepared immediately before making the pH determination, as was the case in the germicidal testing. Most accurate results will therefore be obtained where tests are carried out upon dilutions freshly prepared from stock solutions.

From the data presented here it is evident that much still remains to be learned concerning the most effective concentration of hypochlorite solution for practical use. The results obtained with HTH-15 at various concentrations suggest that the pH value of the solution exerts a much greater influence than the concentration of available chlorine, especially in the more dilute solutions. While the distilled water used in these tests is much more acid than the majority of city water supplies, it would appear that the pH of the water employed to dilute the stock solution, as well as the pH of the latter, may need to be considered in deciding upon the most effective concentration for a given hypochlorite product.

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[10] The new coverslip method of Jensen and Jensen (*9*) is perhaps an exception, although where the disinfectant is not kept in motion the detergent action is much less pronounced.

## SUMMARY

Several methods for evaluating the relative germicidal potency of hypochlorite products have been tested out. Two new methods, an indicator test for pH, and a biological test (with *Staphylococcus aureus* in a milk film upon a microscopic slide) have been developed which are considered promising.

The relative potency of a series of commercial products as determined by several methods is recorded. Discrepancies between the ranking of certain products at 2 and at 100 p.p.m. have been traced to differences in buffer capacity.

Data obtained by glass electrode studies indicate that the influence of the pH of the solution is even greater than that of the concentration of available chlorine, particularly in dilute solutions. This requires consideration in deciding upon the most effective concentration of available chlorine for use in plant practice.

## ACKNOWLEDGMENTS

The writer wishes to express his thanks to Dr. A. G. Lochhead, Dominion Agricultural Bacteriologist, for his advice upon various phases of the work; to Mr. A. H. Jones, B.S.A. for assistance with the germicidal testing, and to Mr. G. S. Field, M.Sc., National Research Council, Ottawa, for assistance in the design and construction of a vacuum tube potentiometer for glass electrode determinations.

## ADDENDUM

Since this paper was written, one has appeared by Devereux and Mallmann entitled "Studies of the Technic to Evaluate the Efficiency of Several Chlorine Sterilizers for Dairy Use". (J. Dairy Sci. 17, 351-360. 1934). The efficiency of two hypochlorites and one chloramine-T product, used at several concentrations as flush solutions in plant practice, was evaluated by three methods. Under the conditions of the experiment (solution in contact with plant equipment for seven minutes) no significant differences were observed between the two hypochlorites (Diversol and HTH–15). Delayed action was observed with the chloramine-T product (Wyandotte Sterilizer). These results emphasize the importance of the period of exposure to the sterilizing solution. Where this is sufficiently lengthy, differences in germicidal speed diminish in importance; where it is brief, as in can and bottle rinsing, they are much more significant. The statement that 6 to 11 p.p.m. of HTH–15 gave as efficient results as 60 to 79 p.p.m. is particularly interesting in view of the results reported in the present paper on the effect of dilution.

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## RESUME

EVALUATION DE LA PUISSANCE GERMICIDE DES COMPOSÉS DE CHLORE—I. HYPOCHLORITES. C. K. Johns, Ferme expérimentale centrale, Ottawa, Ont.

Un certain nombre de moyens pour évaluer la puissance germicide relative des produits d'hypochlorite ont été mis à l'essai. De nouvelles méthodes, un essai d'indicateur pour le pH et un essai biologique (avec *Staphylococcus aureus* dans une pellicule de lait sur une plaque microscopique) ont été développées et donnent de l'espoir. On a noté la puissance relative d'une série de produits commerciaux, déterminée par plusieurs méthodes. Les différences constatées dans le classement de certains produits à 2 et à 100 p.p.m., ont été attribuées à des différences dans la capacité d'oxydation. Les données obtenues par l'étude d'électrodes de verre indiquent que l'influence du pH de la solution est encore plus considérable que celui de la concentration de chlore libre, surtout dans les solutions diluées. C'est là un facteur dont on doit tenir compte dans le choix de la concentration la plus utile de chlore libre pour l'emploi dans la pratique.

# GRAVENSTEINS—TIME OF PICKING IN RELATION TO SPOT SCALD[1]

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[Received for publication April 4, 1934]

A spot scald disease affecting Gravenstein apples was described by Hockey[3] in 1931. In that paper it was suggested that the sucrose content of the fruit might have influenced the development of the scald symptoms. No fruit with a sucrose content over 0.1% was available at the time the scald appeared in the 1930 crop. It was therefore decided that observations on this condition should be made on the 1931 crop.

## Materials and Methods

This "scald" has been observed on Gravenstein and Banks Gravenstein fruits following exposure to light after storage. For the 1931 observations a Banks Gravenstein tree was selected in an orchard which had received the ordinary routine cultural, fertilizer and spraying treatment. The fruit from this tree was picked at intervals of one week from August 26 until September 30, the date of the sixth and last picking. Approximately one bushel of apples was selected at each picking. The fruit was graded for uniformity of size and colour to represent the optimum condition of the fruit on the tree at the time of each picking. It was then placed immediately into common ventilated storage. Records were also taken on percentage colour, size, presence of starch and pressure test of each lot. Ten apples of each sample were used for the starch and pressure tests, and these were then peeled, cored and minced for sugar determinations.

*Starch.*—The iodine-potassium iodide test was applied to thin longitudinal sections of the fruit.

*Pressure Test.*—The modified Magness pressure tester manufactured by D. Baullauf Inc., Washington, D.C., was used throughout with the 7/16 inch tip. A thin peel was first removed before testing.

*Sugars.*—These were determined by the modified Fehling's solution method using the ferrocyanide test to determine the end point in titration. Total sugars were determined by inverting the sucrose in the juice with HCl and subsequently neutralizing with 2n. NaOH. The difference between total and reducing sugars was taken as sucrose.

### COLOUR AND SIZE OF FRUIT AT TIME OF PICKING

Notes were made on the relative amount of colour of each lot of apples, at the time of picking. The apples of the first three pickings had streaked colour only and no blush or solid coloured cheek. The apples of the last three pickings were more solidly coloured and streaked and were altogether typical of the variety, "Banks Gravenstein."

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[1] Contribution No. 398 from the Division of Botany, Experimental Farms Branch, Department of Agriculture, Ottawa, Canada.

[2] Pathologist-in-Charge and Plant Disease Investigator respectively.

[3] Hockey, J. F.—Gravenstein spot scald. Sci. Agr. *13* : 4; 225-227. 1932.

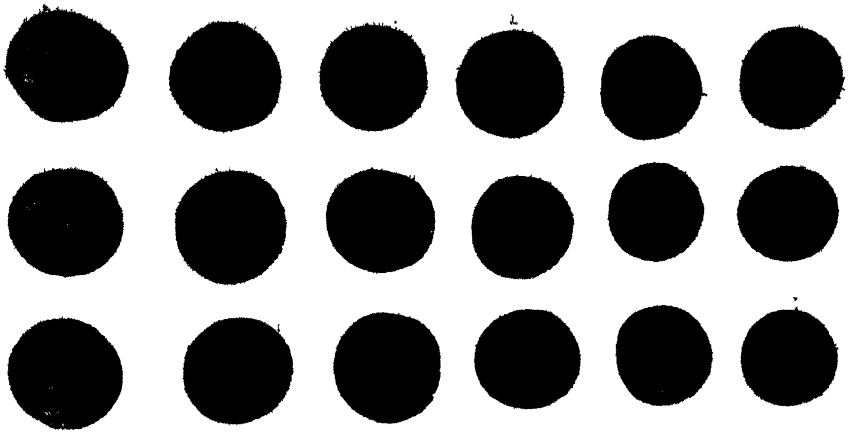

FIGURE 1. Typical size and colour intensity of Gravensteins of six successive dates of picking. Photographed October 27, 1931. Smallest apples are first picking.

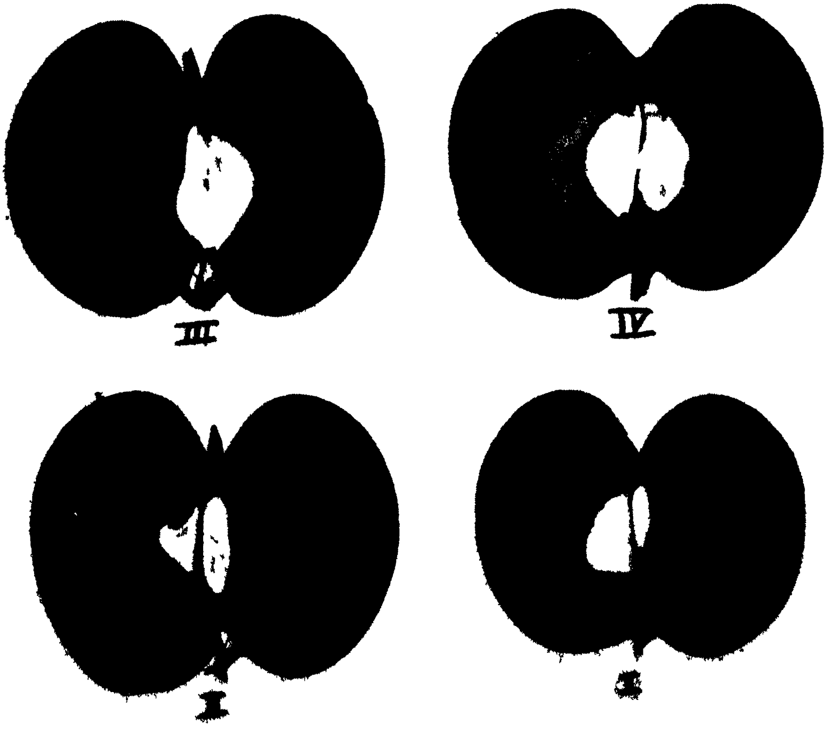

FIGURE 2. Iodine-potassium iodide test for starch photographed Sept. 16, 1931.
I. Picked August 26. II. Picked September 3.
III. Picked September 9. IV Picked September 16.

The intensity of colour and average size of each lot of fruit at the time of picking is given in Table 1. Figure 1 shows representative samples.

TABLE 1.—SIZE AND COLOUR AT TIME OF HARVEST

| Lot | Date picked | Average diameter | No. per brl. | Colour |
|---|---|---|---|---|
| I | Aug. 26 | 2 43 | 585 | 50% streak |
| II | Sept. 3 | 2 59 | 525 | 70% streak |
| III | Sept. 9 | 2 68 | 475 | 75% streak |
| IV | Sept. 16 | 2 81 | 435 | 80% streak and blush |
| V | Sept. 23 | 2 84 | 400 | 85% streak and blush |
| VI | Sept. 30 | 2 93 | 350 | 85% streak and blush |

Climatic conditions are known to affect size and colour of fruit. Table 2 gives a summary of local observations on these conditions during harvest. The week preceding the time of harvesting sample IV had a high mean temperature, one day with a rainfall of 0.28 inch, and sunshine averaging close to 7 hours per day. These conditions, together with the decreasing starch content as shown below, apparently were favourable to the development of colour.

TABLE 2.—CLIMATOLOGICAL CONDITIONS DURING HARVEST

| Period | Temperature in Degrees F. | | Precipitation | | Sunshine |
|---|---|---|---|---|---|
| | Range | Average of daily mean | No. of days | Total inches | Total hours |
| Aug. 26–Sept. 2 | 44° - 80° | 63 7° (1) | 1 | 0 85 | 61 7 |
| Sept. 3–Sept. 8 | 47° - 75° | 60 2° | 5 | 1 33 | 20 5 |
| Sept. 9–Sept. 15 | 42° - 86° | 63 9° | 1 | 0 28 | 48 0 |
| Sept. 16–Sept. 22 | 34° - 65° | 53 2° | 4 | 0 63 | 36 1 |
| Sept. 23–Sept. 29 | 43° - 64° | 52 7° | 6 | 1 72 | 10 7 |

## THE STARCH TEST

Figure 2 shows the relative amounts of starch present in the fruits of the first four pickings on the day of the fourth picking, September 16. The fruit of the fifth and sixth pickings were similar to III, in Figure 2, at the time they were picked. The starch in the fruit of the first three pickings completely disappeared after three weeks in storage. The fruit of the last three pickings did not lose its starch until after four weeks in storage.

The starch content of the fruit at the time of picking was as follows:—

Lots I to III showed starch throughout the flesh;

Lot IV showed starch disappearing from the core area;

Lot V showed starch streaked in flesh, some in core area;

Lot VI showed starch scattered and streaked.

## THE PRESSURE TEST

The average pressure in pounds as determined by the Magness pressure tester, on ten apples at the time of each sampling is given in Table 3.

TABLE 3.—AVERAGE OF PRESSURE TESTS ON GRAVENSTEIN APPLES

| Date | I. | II. | III. | IV. | V. | VI. | Temp. |
|---|---|---|---|---|---|---|---|
| Aug. 26 | 17.2 | — | — | — | — | — | 66 |
| Sept. 3 | 16.1 | 16.0 | — | — | — | — | 60 |
| Sept. 9 | 15.1 | 15 1 | 14.6 | — | — | — | 58 |
| Sept. 16 | 11.6 | 11.2 | 13.9 | 13.9 | — | — | 60 |
| Sept. 23 | 11.4 | 9.2 | 10.3 | 12.9 | 12 7 | — | 55 |
| Sept. 30 | 10.1 | 8.8 | 8.8 | 9.5 | 12.1 | 13.2 | 50 |
| Oct. 7 | 9.9 | 8.7 | 9.3 | 9.7 | 10.0 | 11.3 | 48 |
| Oct. 14 | 9.3 | 8.8 | 9.5 | 8 7 | 8.4 | 8.8 | 49 |
| Oct. 21 | 10.7 | 8.6 | 8.4 | 7.7 | 7.1 | 7.1 | 42 |
| Oct. 28 | 9.9 | 8.2 | 8.3 | 7.1 | 8 3 | 7.2 | 44 |
| Nov. 4 | 9.5 | 8.8 | 7 8 | 7.2 | 7 8 | 7.5 | 44 |
| Nov. 11 | 9.5 | 9.3 | 7.3 | 7 5 | 7.4 | 7.7 | 45 |
| Nov. 18 | 9.2 | 8.3 | 7.5 | 7.4 | 7.3 | 7.8 | 41 |
| Nov. 25 | 8.5 | 6.6 | 7 4 | 7.0 | 6 7 | 6.8 | 50 |
| Dec. 9 | 8.6 | 7.4 | 7.5 | 7.9 | 7.2 | 7.1 | 31 |

By October 21 the fruit of the first two pickings was withered, and that of the third picking was in the same condition the following week. It was fully three weeks later before withering was found in the fruit of the last three pickings.

The pressure tester gives an indication of the firmness of the flesh. The iodine test for starch gives an indication of the physiological condition of the fruit. Fruit which showed the highest starch content and average pressure at time of picking wilted earliest in storage. A comparison of the pressure test and starch test can be made at the time each lot of apples became free from starch. The average tests at this time were 11.6; 9.2; 8.8; 8.7; 7.1; and 7.2 pounds respectively for Lots I to VI. It is evident that firmness of flesh and starch content cannot be used synonymously. The firmness of the flesh varies on the same apple. The coloured side of a fruit will frequently require two pounds more pressure than the green portions. Furthermore, the accuracy of readings from the pressure tester depends on the skill of the operator. The iodine test is a visual black and white test, fool-proof and an indication of the starch content. Since starch gradually disappears in an apple approaching maturity the test for starch is considered a more reliable index of physiological maturity.

## SUGAR CONTENT DURING STORAGE

Sugar analyses were made weekly on samples from storage of each picking until November 25. From these analyses it was found that total sugar increased in the fruit until the iodine test gave a negative reaction for starch. After the disappearance of starch, sucrose and total sugars gradually decreased. Total sugars were higher in Lots III and IV than any other sample. Lot IV maintained the highest sucrose and total sugar content throughout the storage period.

## PRODUCTION OF SPOT SCALD

The first exposure of apples to light to determine their relative susceptibility to spot scald was made on October 7, one week after the last picking. One and one-half hour after exposure to sunlight in a window the fruit from the first two lots showed scald symptoms. Six hours after exposure all the fruit from the first three lots showed typical spot scald. Twenty-four hours later one apple from Lot V had a few very small spots at the stem end. After forty-eight hours' exposure two apples in Lot VI had a few very small spots. The spots were depressed on all fruits. Lot IV was the only one which developed no scald symptoms.

Table 4 presents the sugar analyses made at the time of the first exposure of the apples to light. Lot IV had the greatest amount of reducing and total sugars and developed no spot scald. On the other hand, Lot VI developed the least spot scald and had the lowest amount of total sugar. Lots I, II and III developed symptoms of the disease a few hours after exposure and there is an appreciable difference in sucrose and total sugar content of the first two and third pickings.

TABLE 4.—SUGARS IN GRAVENSTEINS. OCTOBER 7, 1931.

| Lot | Reducing | Sucrose | Total |
|---|---|---|---|
| I | 7.64 | 0.26 | 7.92 |
| II | 7.59 | 0.37 | 7.96 |
| III | 7.30 | 1.49 | 8.79 |
| IV | 8.33 | 1.45 | 9.78 |
| V | 6.37 | 1.69 | 8.06 |
| VI | 6.54 | 1.24 | 7.78 |

A similar exposure of fruit to light was attempted two weeks later. The weather was very dull and sunlight totally lacking. After forty-eight hours' exposure all the fruit from all lots except No. IV had developed the trouble. In the latter only the poorest coloured fruit showed scald. It may be noted here that in these tests, apples from Lot IV were less waxy than any of the others.

A subsequent exposure of fruit from the six pickings gave the same results as the two above experiments, namely, that fruit from samples I, II, and III developed much more spotting than from the other three, and fruit from Lot IV was the least affected.

## DISCUSSION

The data presented above do not show conclusively that any one factor under observation was directly responsible for the predisposition of the fruit to spot scald. At the time of the first exposure of the samples to light the first three lots were the only ones containing no starch. When the second exposure was made no fruit was found to contain starch. The fruit in Lots I and II contained less than 0.4% sucrose in the first exposure compared to 1.2 to 1.7% in the other four lots. Results from subsequent determinations of sucrose and total sugar content did not support the hypothesis that these have any influence on the susceptibility to scald.

The differences in colour intensity between the first three samples and the last three samples coincides inversely with the intensity of spot scald symptoms.

One sample of Gravenstein was obtained, from a local warehouse, which had been in cold storage four weeks. The fruit had been grown in an orchard under sod culture and sprayed with lime sulphur, and had been picked on September 25 and stored a week later. This fruit spotted on exposure to light equally as much as the fruit from sample III. It was better coloured than the latter sample, being practically equal to Lot IV in this respect. Analysis for total sugar and sucrose showed a condition almost identical with that of fruit from Lot V. The fruit was firm and free from starch. It was apparent that cold storage did not prevent the appearance of the scald symptoms.

Tiller[4] described a similar condition occurring in New Zealand, and also in England, on fruit which had been exposed for sale in shop windows, as that reported here. Early picking and storage at 32° F. are suggested as partial controls for the Lord Wolseley variety. He concludes that "the spotting is a photo-chemical effect, and not a temperature effect." In a previous paper (loc. cit.) the writer stated "it is probable that a photo-chemical reaction is at least partly responsible for the symptoms."

There is considerable commercial significance to the data presented in this paper. When size, colour, and sugar content are considered there is a decided difference between the fruit from the first and the fourth pickings. Three more weeks on the tree greatly increased the quality of the crop.

## SUMMARY

1. Gravensteins picked at the time when most of the starch had disappeared from the core area and while there was an appreciable amount in the flesh of the apple, developed the least amount of spot scald.
2. The amount of sucrose and total sugars present in the fruit had little or no effect on the prevalence of the disease.
3. Harvesting the fruit when most of the starch had disappeared from the core area gave fruit of larger size, deeper colour and better keeping quality than earlier picked fruit of the variety Gravenstein.
4. The iodine-potassium iodide test for starch is considered superior to the mechanical pressure tester as a method for determining the picking maturity in apples maturing about the same time as Gravensteins.

## RESUME

### POMMES GRAVENSTEIN—EFFET DE LA DATE DE LA CUEILLETTE SUR L'ÉCHAUDURE.

J. F. Hockey et J. A. Boyle, Laboratoire fédéral de pathologie végétale, Kentville, N.-E.

Une échaudure qui affecte les pommes Gravenstein a été étudiée. On voulait voir si la proportion de sucrose dans le fruit exerce une influence sur le développement de la maladie. Les pommes qui ont développé le moins d'échaudure sont celles qui ont été cueillies au moment où la plus grande partie de l'amidon avait disparu de la région du cœur, et lorsqu'il y en avait une quantité appréciable dans la chair de la pomme. La quantité de sucrose et de sucres totaux présente dans le fruit n'avait que peu ou point d'effet sur la fréquence de la maladie. Les fruits récoltés lorsque la plus grande partie de l'amidon avait disparu de la région du cœur étaient plus gros, avaient une couleur plus foncée et se sont conservés mieux que les fruits cueillis plus tôt. On considère que l'essai d'iodure de potassium pour l'amidon est supérieur à la pression mécanique comme moyen de déterminer le degré de maturité pour la cueillette, dans les pommes qui mûrissent à peu près en même temps que les Gravensteins.

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[4] Tiller, L. W.—A superficial spotting disease of the Lord Wolseley Apple. N.Z. Jour. Sci. Tech. *14*; 2: 111-113. 1932.

# A NOTE ON THE VITAMIN A AND D CONTENT OF OIL FROM THE TESTES OF A STURGEON[1]

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[Received for publication May 7, 1934]

A lake sturgeon[2] (*Acipenser fulvescens*) caught in Lake Ontario in the summer of 1928 was kept at room temperature for a few days, during which time a very large quantity of oil oozed from the testes of the fish. This oil was collected and filtered through Chardin paper. It was reddish brown in colour and had a rather acrid odour. The vitamin content of this oil was assayed but unfortunately the liver was not available.

## Vitamin A Assay

1. *Biological.*—The vitamin A potency of this oil was assayed by the technique of Sherman and Munsell (*3*). The oil was fed in daily doses of 0.02, 0.04, 0.06, 0.08 and 0.16 grams after cessation of growth. Vitamin D was supplied by viosterol (irradiated ergosterol). All rats fed these various amounts continued to lose weight but the larger doses definitely prolonged the survival period. The oil had no curative influence on xerophthalmia.

2. *Colorimetric.*—The oil was colorimetrically assayed for vitamin A potency by the technique recommended by the Accessory Food Factors (Vitamins) Committee (*1*). A faint blue colour, less than one unit, was developed.

This oil, although probably containing a very small amount of vitamin A, was for all practical purposes, devoid of the vitamin.

## Vitamin D Assay

The antirachitic potency of the oil was estimated by the preventive type of assay, previously described (*2*), using Steenbock's rachitogenic diet 2965. The findings are summarized in Table 1.

Table 1.—Antirachitic potency of sturgeon testes oil

| Diet | X-ray findings | Inorganic phosphate in plasma (P. in mgs. per 100 cc.) |
|---|---|---|
| Normal | Normal | 5.2 |
| Rachitogenic No. 2965 | +Rickets | 1.8 |
| Rachitogenic + .02g. oil | +Rickets | 1.8 |
| Rachitogenic + .01g. oil | +Rickets | 2.1 |
| Rachitogenic + .004g. oil | ++Rickets | 1.7 |

These results showed that this oil contained extremely little, if any, vitamin D.

Since this oil was a sample from one fish only no general conclusion can be made as to the presence or absence of vitamins A and D in the testes of the ganoids. The fish was apparently in normal condition. Many investigators have established the presence of vitamin D in the body as well as the liver oils of a number of fish, of both salt- and fresh-water habitat. Zilva, Drummond and Graham (*4*) found oil from the gonads of codfish to be very potent in vitamin A. If the absence of fat-soluble vitamins in the ganoids can be substantiated, a further investigation of the potency of oils from various fish families might give results indicating that vitamin D may be synthesized in the tissues of fishes and that the ability to synthesize the vitamin is confined to particular types.

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[1] A contribution from the Department of Biochemistry, University of Toronto, and the Department of Poultry Husbandry, Ontario Agricultural College.

This work formed part of a thesis submitted by the author for the degree of Doctor of Philosophy, in the Department of Biochemistry, University of Toronto.

[2] This material was kindly supplied by the Ontario Fisheries Research Laboratory.

## SUMMARY

The oil from the testes of a sturgeon (*Acipenser fulvescens*) is shown to be devoid of vitamins A and D.

## REFERENCES

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2. BRANION, H. D. The fat soluble vitamin content of the liver oil of the burbot. Sci. Agric. 14, —. 1934. (In Press).
3. SHERMAN, H. C. and MUNSELL, H. E. The quantitative determination of vitamin A. Jour. Amer. Chem. Soc. 47 : 1639. 1925.
4. ZILVA, S. S., DRUMMOND, J. C., and GRAHAM, M. The relation of the vitamin A potency of the liver oil to the sexual condition and age of the cod. Biochem. Jour. *18* : 179. 1924.

# BOOK REVIEWS

SUPPRESSION OF WEEDS BY FERTILIZERS AND CHEMICALS. H. C Long, B.Sc. (Agric.) of the Ministry of Agriculture and Fisheries. Published by H. C. Long, "The Birkins," Orchard Road, Hook, Surbiton, Surrey, Eng. March 1934. Price 2s. net.

In recent years many experiments have been conducted in different parts of the world in order to study the effect of certain chemical substances on the control of weeds. Mr. Long in his book "Suppression of Weeds by Fertilizers and Chemicals" has given a concise and useful summary of the more important results obtained from these experiments.

Sir A. D. Hall in the foreword to this booklet says 'Mr. Long has been at great pains to sift the voluminous literature which is scattered throughout many periodicals, foreign as well as English. He has put the data into a practical form and provided references for those who wish to consult the original papers."

Very useful data are presented in the first chapter of this booklet to show the great difference in yield between clean and weedy crops. The loss of crop yield due to weeds is frequently 40 to 50 per cent.

The chapters dealing with commercial fertilizers are most interesting. Many outstanding results are recorded which show the marked influence of ammonium sulphate, calcium cyanamide, finely ground kainit and lime on the control of certain weeds.

The effects of sulphates of copper and iron, sodium and potassium chlorates, compounds of arsenic and a number of other chemicals on the suppression of weeds are also discussed.

The booklet contains numerous illustrations which show in a striking manner the effect of certain chemical substances on the control of weeds. —Geo. Knowles

BUMBLEBEES AND THEIR WAYS. Otto Emil Plath. The Macmillan Company of Canada. 1934. Price $4.75.

This volume forms a fascinating addition to our knowledge of this interesting group, supplementing the researches of Sladen and Hoffer on the habits of the European species of this family. As stated by Dr. W. M. Wheeler, "It fulfills the function of an accurate taxonomic guide on our common North American species and constitutes, in its emphasis on the behavior pattern of each species, an outstanding example of the many up-to-date contributions with which the younger entomologists are steadily enriching their science." The volume embodies the work of thirteen summers devoted to observation and experiment in an effort to solve the many interesting problems that this group presents. The impressive amount of new material which the author has managed to compress into his book is pleasingly presented in non-technical language which makes it of equal interest to the entomologist and the nature student. —W. H. Brittain

# THE ECONOMIC ANNALIST

A REVIEW OF AGRICULTURAL BUSINESS PREPARED QUARTERLY BY THE AGRICULTURAL ECONOMICS BRANCH, DEPARTMENT OF AGRICULTURE, OTTAWA

Vol. IV, No. 2. June, 1934

## THE ECONOMIC SITUATION

PREPARED IN THE AGRICULTURAL ECONOMICS BRANCH, DEPARTMENT OF AGRICULTURE, OTTAWA, FROM BASIC DATA COLLECTED BY THE DOMINION BUREAU OF STATISTICS

The index number of wholesale prices in Canada was unchanged at 71.1 in May. The sub-indexes of vegetable products; wood, wood products, and paper; iron and its products; chemicals and allied products advanced, whereas those of animals and their products; fibres, textiles, and textile products; non-ferrous metals and their products, and non-metallic minerals declined.

*Retail Prices.*—The total index of retail prices, rents, and costs of services declined from 79.6 in April to 78.7 in May. The food index dropped from 71.0 to 68.6. The fuel index advanced slightly but the index of rentals was 79.7 as compared with 80.4 in previous months. The latter index is computed only at October 1 and May 1.

*Retail Sales.*—The value of retail sales was lower in April as compared with March. The index therefore fell from 73.6 to 72.1 (1929 = 100), although it should be remembered that the March index was affected by Easter business. Groceries and meats moved downward from 83.0 to 75.1. Candy sales dropped from 93.0 to 66.5. Sales in general and departmental stores declined from 66.8 to 65.2. On the other hand the index of the value of boot sales rose from 70.1 to 76.5; that of clothing advanced from 87.4 to 92.9 and hardware from 72.1 to 104.3.

*Physical Volume of Business.*—The indexes of physical volume of business, industrial production, agricultural marketings and cold storage holdings are not available as this is being written. The reader is referred to the table of indexes for changes which may have taken place.

*Agricultural Products.*—The index of wholesale prices of Canadian farm products advanced from 55.4 in April to 56.9 in May. Field products rose from 48.7 to 51.1. Higher prices for grains contributed largely to this advance. The average price of No. 1 Manitoba Northern wheat was 70.6 cents in May as against 65.5 cents in April. Similarly prices of No. 2 C. W. oats were 34.6 and 32.4 cents respectively. No. 1 C. W. flax was 157.3 as compared with 149.7. No. 2 C.W. rye was 46.4 in May as against 44.1 in April, while No. 3 C. W. barley averaged 38.1 and 36.9 cents in the respective months. The index of animal products receded from 66.6 to 66.5. Lower prices for wool and fresh milk chiefly affected this index. Prices of cattle were also lower but those of hogs and lambs advanced. Egg prices at Montreal, Toronto and Vancouver were higher than in April. Butter prices generally were lower.

*Cold Storage Holdings.*—Cold storage holdings of creamery butter on June 1 were 7.6% above the five year average at that date. Stocks of cheese were 10.6% higher than the average. Supplies of cold storage eggs on the other hand were 11.7% lower. Total stocks of pork were 16.8% below the average. Holdings of beef were 12.6% under and those of veal 10.8% less than the five year average. Supplies of poultry in storage were 4.4% lower.

## ANNUAL AND MONTHLY INDEX NUMBERS OF PRICES AND PRODUCTION COMPUTED BY DOMINION BUREAU OF STATISTICS

| Year | Wholesale Prices 1926 = 100 | | | | Retail prices and cost of services (5) | Production (6) 1926 = 100 | | | |
|---|---|---|---|---|---|---|---|---|---|
| | All commodities (1) | Farm products (2) | Field products (3) | Animal products (4) | | Physical volume of business | Industrial production | Agricultural marketings | Cold Storage holdings |
| 1913 | 64.0 | 62.6 | 56.4 | 77.0 | 65.4 | | | | |
| 1914 | 65.5 | 69.2 | 64.9 | 79.0 | 66.0 | | | | |
| 1915 | 70.4 | 77.7 | 76.9 | 79.2 | 67.3 | | | | |
| 1916 | 84.3 | 89.7 | 88.4 | 92.3 | 72.5 | | | | |
| 1917 | 114.3 | 130.0 | 134.3 | 119.6 | 85.6 | | | | |
| 1918 | 127.4 | 132.9 | 132.0 | 134.7 | 97.4 | | | | |
| 1919 | 134.0 | 145.5 | 142.4 | 152.5 | 107.2 | 71.3 | 65.5 | 48.1 | 47.1 |
| 1920 | 155.9 | 161.6 | 166.5 | 149.9 | 124.2 | 75.0 | 69.9 | 52.6 | 94.2 |
| 1921 | 110.0 | 102.8 | 100.3 | 108.5 | 109.2 | 66.5 | 60.4 | 65.2 | 86.4 |
| 1922 | 97.3 | 86.7 | 81.3 | 99.1 | 100.0 | 79.1 | 76.9 | 82.6 | 82.8 |
| 1923 | 98.0 | 79.8 | 73.3 | 95.1 | 100.0 | 85.5 | 83.8 | 91.4 | 87.6 |
| 1924 | 99.4 | 87.0 | 82.6 | 97.2 | 98.0 | 84.6 | 82.4 | 102.5 | 114.9 |
| 1925 | 102.6 | 100.4 | 98.1 | 105.7 | 99.3 | 90.9 | 89.7 | 97.2 | 108.6 |
| 1926 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.9 | 100.0 |
| 1927 | 97.7 | 102.1 | 99.9 | 105.7 | 98.4 | 106.1 | 105.6 | 103.6 | 110.0 |
| 1928 | 96.4 | 100.7 | 92.6 | 114.3 | 98.9 | 117.3 | 117.8 | 146.7 | 112.8 |
| 1929 | 95.6 | 100.8 | 93.8 | 112.5 | 99.9 | 125.5 | 127.4 | 101.1 | 109.6 |
| 1930 | 86.6 | 82.3 | 70.0 | 102.9 | 99.2 | 109.5 | 108.0 | 103.0 | 128.4 |
| 1931 | 72.2 | 56.3 | 43.6 | 77.6 | 89.6 | 93.5 | 90.4 | 99.0 | 125.7 |
| 1932 | 66.7 | 48.4 | 41.1 | 60.7 | 81.4 | 78.7 | 74.0 | 114.3 | 120.1 |
| 1933 | | | | | | | | | |
| Jan. | 63.0 | 43.6 | 35.1 | 57.9 | 79.1 | 68.1 | 62.2 | 56.1 | 112.0 |
| Feb. | 63.6 | 43.0 | 36.0 | 54.7 | 78.4 | 67.0 | 60.0 | 76.5 | 127.6 |
| Mar. | 64.4 | 44.7 | 38.0 | 56 0 | 77.8 | 68.4 | 62.5 | 129.0 | 135.8 |
| April | 65.4 | 46.8 | 41.1 | 56.4 | 78.1 | 69.8 | 65.1 | 104.1 | 112.7 |
| May | 66.9 | 51.2 | 46.9 | 58.4 | 77.0 | 76.4 | 72.7 | 95.4 | 110.4 |
| June | 67.6 | 52.6 | 49.4 | 57.9 | 77.0 | 82.2 | 79.8 | 221.9 | 119.9 |
| July | 70.5 | 60.1 | 60.8 | 59.0 | 77.2 | 84.1 | 82.6 | 221.9 | 119.9 |
| Aug. | 69.4 | 57.0 | 54.9 | 60.5 | 78.6 | 89.8 | 89 5 | 197.2 | 114.2 |
| Sept. | 68.9 | 54.7 | 49.5 | 63.4 | 78.8 | 90.8 | 90.2 | 101.1 | 115.7 |
| Oct. | 67.9 | 51.4 | 44.6 | 62.8 | 77.9 | 88.2 | 87.4 | 70.5 | 112.7 |
| Nov. | 68.7 | 53.8 | 46.7 | 65.8 | 78.1 | 85.5 | 83.9 | 41.8 | 111.1 |
| Dec. | 69.0 | 53.3 | 45.3 | 66.6 | 78.4 | 86 2 | 85.1 | 30.7 | 107.6 |
| 1934 | | | | | | | | | |
| Jan. | 70.6 | 55.3 | 47.9 | 67.8 | 78.7 | 86.8 | 84.5 | 48.2 | 108.1 |
| Feb. | 72.1 | 58.0 | 49.3 | 72.5 | 79.2 | 86.4 | 84.0 | 67.1 | 98.6 |
| Mar. | 72.0 | 56.5 | 49.5 | 68.3 | 80.2 | 93.1 | 92.0 | 63.8 | 97.0 |
| Apr. | 71.1 | 55.4 | 48.7 | 66.6 | 79.6 | 92.6 | 91.4 | 56.9 | 94.5 |
| May | 71.1 | 56.9 | 55.4 | 66 5 | 78.7 | 99.6 | 99.4 | 130 6 | 102 6 |

1. See Prices and Price Indexes 1913-1928, pp. 19-21, 270-289 and 1913-1931, p. 15.

2. Wholesale prices of Canadian products of farm origin only. See Prices and Price Indexes 1913–1931, p. 33, and Monthly Mimeographs 1933 and 1934.

3. Wholesale prices of grains, fruits and vegetables.

4. Wholesale prices of Animals and Animal Products.

5. Including foods, rents, fuel, clothing and sundries, See Prices and Price Indexes 1913-1928, pp. 181-185, 290-293. 1926=100.

Prices and Price Indexes 1913-1931, p. 122, and Monthly Mimeographs 1933-1934.

6. Monthly Review of Business Statistics, p. 8, and Monthly Indexes of the Physical volume of business in Canada, supplement to the Monthly Review of Business Statistics, November, 1932.

*Crops.*—Crop prospects improved as a result of the general rains during the second week of June. The effect of drought in sections of Eastern Canada are, however, still apparent. Conditions in the Prairie Provinces have become more hopeful although drought, soil drifting, and grasshoppers have all affected cereal production.

*Dairy Production.*—The Dairy News Letter, June 15th, gives the gradings of cheese from December 4, 1933, to June 2, 1934 as 87,761 boxes as compared with 118,279 boxes graded during the period November 28, 1932, to June 3, 1934.

Production of butter for the four months ending April 30, 1934, was 39,766,747 pounds as against 38,185,326 pounds during the first four months of 1933, an increase of 4.2%. Among the provinces, Prince Edward Island and Saskatchewan show decreases of 2.0 and 5.3% respectively. In New Brunswick production increased 48.6%. Nova Scotia creameries increased output 13.2% and in Manitoba production was 6.1% higher. In Alberta and Quebec output was slightly over 5% above that in 1933.

*Prices in Great Britain.*—The Board of Trade index number of wholesale prices (1913 = 100) was 103.8 in March compared with 97.6 in March, 1933. This index did not fluctuate a great deal in 1933; it rose from 97.2 in April until February, 1934, when it reached 105.3. The cost of living index computed by the Ministry of Labour was 139 in April of this year whereas in April, 1933, it was 137. The peak during the past twelve months was reached in December when this index was 143.

The index of prices of agricultural products (1911-1913 = 100) in Great Britain was 108 in March of this year as compared with 102 in March, 1933. During 1933 this index varied from 100 in June to 109 in December. It rose to 114 in January, 1934, but receded to 112 in February and fell another 4 points in March. The importance of this market for Canadian agricultural products emphasizes the necessity of close examination of price movements in Great Britain.

## SASKATCHEWAN MILK ENQUIRY, 1933

The report of the Saskatchewan Milk Enquiry Commission prepared by Dr. Wm. Allen of the University of Saskatchewan, indicates that the problems affecting the marketing of fluid milk in Saskatchewan, except for local conditions, do not differ greatly from those in other provinces. Local differences, such as shortage of feed supplies, cause production costs to be high in some localities and have placed farmers in a precarious position. Surplus milk, which sometimes reaches 50% of the total milk supply, is a most serious factor in the marketing situation. Surplus of plants and general facilities for milk distribution causes costs of marketing to be high and reduces the price the producer receives. Milk distributors are confronted not only by the problem of maintaining a sufficient volume of milk to operate economically but also by the cost of special services given, bottle losses and bad debts. Incomplete enforcement of public health regulations in many localities is causing trouble and is bound to cause more trouble in the future if it continues.

In order to cope with the present situation, the commission advises that the powers of the Local Government Board be extended to include the regulation and control of the production, distribution and marketing of the milk supplies of the cities of the province along lines similar to those authorized in the Provinces of Manitoba and Alberta, the costs of this regulation and control to be borne by the industry.

It is recommended that power be given the Local Government Board to demand standard reports at regular intervals from distributors of market milk to facilitate current examinations of the distribution system.

It is also suggested that local authorities should attempt more rigid enforcement of health regulations, where enforcement is lax. Failing this it is proposed that provincial legislation be set up to take over the control of inspection and licensing of farms producing milk for city consumption, and of plants and agencies handling milk.

Because of the wide variation in quality of milk supplied to the cities and the need for securing a safer milk supply, and because the institution of uniform or similar standards and regulations throughout the market milk industry of the prairie provinces would be highly beneficial, the authorities responsible for the supervision of the production and distribution of milk in Saskatchewan should co-operate with authorities in Manitoba and Alberta in studying this matter fully and making such recommendations as may be warranted with a view to securing appropriate action.

# THE NATURAL PRODUCTS MARKETING ACT, 1934

J. F. Booth[1]

The Natural Products Marketing Act, which received third reading in the House of Commons, Ottawa, on June 7th, is an attempt to give to Canada legislation similar to that at present found in the statutes of the United Kingdom, Australia, and other parts of the Empire. Legislation giving some degree of control over marketing of such products, mainly agricultural, is also to be found in most of the countries of Europe, as well as in other parts of the world. Of necessity, such legislation differs, but a survey of the principles involved leads definitely to the conclusion that underlying all such efforts is the intent to regulate or control either by organizations set up with government sanction or by boards or commissions operated by the state.

It is to be expected that legislation of this nature introduced in Canada would differ to some extent from that to be found elsewhere. In many respects, however, the Canadian Act, if it becomes law in its present form, will resemble the enactments of the United Kingdom and of Australia. In some respects, too, it resembles legislation that was in effect in British Columbia for several years and which was ultimately declared ultra vires because it conferred authority which the courts held was not within the jurisdiction of the provincial legislature.

*Products to be Dealt With.*—It was considered desirable to make the provisions of the Natural Products Marketing Act broad enough to cover, in addition to agricultural products, such products as lumber and fish. The section dealing with this matter definitely specifies most of our major, and some of the less important, agricultural products and states that such other natural products of agriculture and of the forest, sea, lake, or river and any article of food or drink that is wholly or partly manufactured or derived from any such product may be made subject to the provisions of the Act by the Governor in Council. It is not intended that the Act will deal with secondary products other than those classified as food or drink.

*Administration.*—The Act is to be administered by "the Minister designated by the Governor in Council". This is understood, following a statement made in Committee of the House, to mean the Minister of Agriculture.

*Machinery of Regulation.*—The Act provides for a board to be known as the Dominion Marketing Board which is to consist of such number of persons as the Governor in Council may from time to time determine. The Board may employ professional and technical assistants, and shall be a body corporate with head office at Ottawa. It shall advise the Minister on matters pertaining to the Act and regulations made thereunder.

The Dominion Board, referred to in the Act as "the Board", will be financed out of monies to be appropriated by Parliament. In addition to the funds necessary for this purpose it is also provided that Parliament may make available money to assist in the organization of local boards and to meet expenditures incurred in connection with certain operations in the nature of marketing or regulation of marketing that may be undertaken by the Dominion Board in accordance with authority conferred by a special section dealing with this matter.

In addition to the Dominion Board, the Act provides for the setting up of local boards which will be the creation of persons engaged in production and/or marketing of a natural product. Any group of persons engaged in either or both of the functions above mentioned may petition the Governor in Council to approve a "scheme" for the regulation of the marketing of a natural product. The Minister upon receipt of the petition will refer it to the Dominion Marketing Board with a request that the Board consider the expediency thereof. It is assumed that the Board will consider and investigate the desirability of such an undertaking. If the Board reports favourably upon the proposal, the Minister may then recommend its approval either with or without a vote of those who will be directly affected by its operations. The decision by the Minister on whether or not a poll will be required is to be based upon the question of whether those submitting the petition in the first instance adequately represent all persons whose activities will be subject to the regulations of the local board.

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The scheme, which is the instrument designed to give effect to the wishes of those concerned with the production and/or marketing of the product to be dealt with, must state in sufficient detail all of the powers that are desired and which may be conferred within the scope of the Act, the arrangements for a poll, if one is proposed, the geographical limits of the territory to be included, whether the scheme is to relate to all of the regulated product or only to such part as enters inter-provincial or export trade, the number of persons who shall comprise the local board and the basis of their selection, and such other information as may be required by the Minister. The language used in dealing with the scheme, and with the local board that will administer it, clearly indicates that the intention is to give to those interested an opportunity to regulate their own business under stated conditions. The local board in charge of the scheme will be subject to the general supervision of the Dominion Marketing Board.

*Powers Conferred.*—The powers conferred by the Act are vested in the Dominion Board with the provision that the latter may delegate to a local board such of its powers as may be requested by a scheme. It is not intended that these powers will be used by the Dominion Board when a local board has been established or when producers or marketers of the product in question are in a position to create a local board. The Act does provide, however, that under conditions that might be referred to as unusual, and where no local board exists, the Dominion Board may undertake the regulation or the marketing of a product in interprovincial or export trade and that it may engage in such activities directly or in co-operation with local boards or through any agency which it may establish. A careful reading of this provision of the Act, and consideration of it in relation to the legislation as a whole, makes it quite clear that the powers thereby conferred are not to be used under ordinary circumstances. In his presentation of the Act to Parliament, the Minister made it plain that it was not intended to use this provision to force an organization on an unwilling group or as a substitute for local action.

With respect to the powers conferred by the Act it is significant that they relate only to the regulation of marketing, except in a case such as referred to where action is taken by the Dominion Board. Local boards will be given power to "regulate the time and place of marketing the regulated product, and to determine the manner of distribution and the quantity and quality or grade of the regulated product that shall be marketed by any person at any time, and to prohibit the marketing of any of the regulated product of any grade or quality." In this clause is embodied the fundamental principle of the legislation, namely, that of regulation with governmental approval. It is not intended that local boards shall engage in the buying or selling of products, nor that they shall disrupt organized trade.

In carrying out the powers conferred by the section quoted, a local board may provide for; (1) the conduct of a pool; (2) the compensation of persons who sustain losses under specified conditions; (3) the provision of facilities for processing or otherwise conditioning the regulated product, and (4) assistance in the conduct of research work. The local board, in the conduct of its operations, may co-operate with any board or agency established under the law of any province.

To enable it to enforce the authority which it exercises, the local board may require the registration or licensing of all persons engaged in the production or marketing of the regulated product. The term "regulated product", as defined by the Act, means a natural product to which a scheme approved under this Act relates.

*Constitutional Authority.*—Provision has been made that the Dominion Board may authorize any marketing board or agency established under the law of a province to be, and to exercise the functions of, a local board under the terms of the Natural Products Marketing Act and the Board may further exercise, or confer upon a local board established under the Act authority to exercise, any power conferred upon it by or pursuant to provincial legislation. Under such a provision a local board created either under the jurisdiction of a province or under the Natural Products Marketing Act may be given the authority to deal with both intra and inter-provincial marketing.

*Financing of Local Boards.*—Authority is granted by the Act for the collection and disbursement by a local board, as agent of the Dominion Board, of such funds as may be necessary for the conduct of its operations. A local board established under the law of any province may be granted the same authority. The monies necessary for the administration of a scheme may be raised by the imposition of charges or tolls against the regulated product.

*Special Powers to Market.*—Reference has already been made to the special powers given the Dominion Board to market or to regulate the marketing of a natural product. The limitation on this power is that there shall be no existing local board available for that particular product, and further that the Dominion Board shall be concerned only with interprovincial and/or export trade. Under such circumstances, and if the Minister is satisfied that the conditions of marketing are such as to warrant action, he may authorize the Dominion Board to act accordingly.

*Restriction of Imports and Exports.*—The provisions of the British Marketing Act of 1933 find their counterpart in Section 12 of the Canadian legislation which empowers the Governor in Council to regulate or restrict the importation into Canada of any natural product that enters Canada in competition with a regulated product. The Dominion Act, however, goes a step farther in this respect,—it also permits the Governor in Council to make orders or regulations to regulate or restrict the exportation from Canada of any natural product.

The provision with respect to exports, since it refers to "any natural product," is broader than that applied to import trade.

*Investigation and Spreads.*—There is a second part to the Act which is only indirectly related to the first part. It deals with "investigations" and "spreads." A spread, as briefly defined, is the charge made by any person for selling, storing, packing and conditioning a natural or regulated product. It also includes the difference between the price at which a natural product is purchased and the price at which it is sold, and in the case of a product that has been processed or converted into another form, it includes the difference between the price of the natural product and the sale price of the product resulting therefrom.

It is provided that the Minister may, at the request of the Board or upon his own initiative, authorize an investigation into the cost of production, wages, prices, spread, trade practices, and other matters relating to the production and marketing of a natural or regulated product, or any product derived therefrom.

If, as a result of an investigation which, it is inferred, may be conducted by officers of the Government, the Minister believes that a further inquiry is necessary he may appoint a committee representative of producers, persons engaged in the marketing, and consumers, to conduct such an inquiry. A committee so appointed shall have the powers of a commissioner appointed under the Inquiries Act and may investigate all operations occurring in connection with or in the course of marketing, adaptation for sale, processing, or conversion of a natural or regulated product for the purpose of ascertaining the spread that is received by any persons in the course of such operations. The Committee may after investigation report whether in its opinion the spread received is detrimental to or against the interests of the public

*—Continued at bottom of page 32*

# MILK CONSUMPTION IN MINNEAPOLIS

The results of a survey of milk consumption in Minneapolis conducted in 1934 were reported in "Minnesota Farm Business Notes," May 20, 1934. This report was prepared by W. C. Waite and R. W. Cox.

Data on milk consumption were obtained from 2,187 Minneapolis families who were located in 230 widely scattered areas and represented a good cross section of the city. Per capita milk consumption was found to be 0.85 pint per day. Studies in other cities indicated that per capita consumption was 0.77 pint in Philadelphia (1929), 0.72 pint in Newark (1920), and 0.85 pint in Boston (1930). The figure for Minneapolis is significant considering that studies in other cities were made in more prosperous times.

A greater proportion of milk was used for liquid consumption as the rate per capita increased; for example, in families consuming at rates between 0.4 and 0.8 pint per day per person, 52% of the milk was used for drinking, while in the families consuming at rates between 1.2 and 1.6 pints, 64% was used for liquid consumption.

Income did not appear to have as great an influence on milk consumption as it does on the other dairy products. Nearly all families, regardless of income levels, reported the purchase of fluid milk Moreover, per capita consumption did not vary greatly except in the lowest income classification when it was 0.77 pint per capita as compared with 1.00 pint per capita in the group showing the highest rate of consumption. The slight decline in the highest income group probably was due to the greater consumption of cream in that group (Table 1).

The differences in consumption which appear in Table 1 may be explained by the fact that in the lower income group fewer adults were drinking milk than in the high income classification. This tendency was even more marked in the group of relief families. A probable source of an increase in milk consumption therefore lies in persuading adults, particularly in the low income groups to drink milk. An increase in the income of the lowest group may be expected to slightly increase milk consumption by the children, and would probably materially increase the consumption by adults.

TABLE 1.—PER CAPITA CONSUMPTION OF MILK AT VARIOUS INCOME LEVELS, MINNEAPOLIS, 1934

| Per capita income | Per capita consumption pints per day |
|---|---|
| Under $300 | 0 77 |
| $300–$599 | 0 93 |
| $600–$899 | 1 00 |
| $900 and above | 0 97 |
| Relief families | 0 69 |
| All families | 0 85 |

Presence of children in the family is naturally an important factor in milk consumption. For example, in families with two adults and no children per capita consumption averaged 0.95 pint per day, while in families of two adults and two children per capita consumption averaged 1.04 pints per day.

In all income levels, more was spent for fluid milk than any other dairy product. Over 50% of the expenditure on dairy products in the low income group was used for the purchase of fluid milk. This declined to 36.5% in the highest income group. In terms of butterfat, however, fluid milk is not so important, accounting for 26.7% of the intake in the low income group and 20.4% in the high income group. On all income levels, butter was over twice as large a source of butterfat.

As per capita income increased, expenditures on dairy products increased, but at a less rapid rate than other food costs and the proportion of the dollar expended for food which was spent on dairy products declined. There was a decrease from an expenditure of about 30% of the total food costs in the lowest income group to 22% in the highest income group.

# ASSESSMENT OF FARM PROPERTY IN ONTARIO

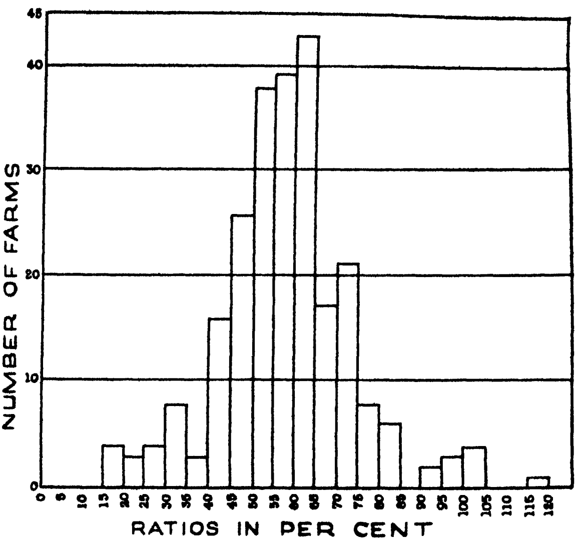
S. C. Hudson[1]

The general property tax, under which the tax on farm property is administered, is essentially a tax on ownership or possession, the total taxes to be raised being allocated on the basis of the value of the property possessed by the individual tax payer. The major responsibility for an equitable distribution of the burden of taxation under this system rests, therefore, with the assessor who evaluates the holdings of the tax payers.

## METHOD OF ASSESSMENT

Assessments in Ontario are on the township basis. Each township, incorporated village, town, and city appoints its own assessor, making a total for the province of about 900 assessors, not including deputies. No special qualifications are prescribed for the office of assessor, applications in rural areas usually being received in the form of tenders. Unless otherwise provided by by-law, each assessor is required to begin to make his roll, each year, not later than February 15th and must have it completed, affirmed, and in the hands of the clerk of the municipality by April 30th, at whose office it is to be available for inspection by all persons interested. Appeals against an assessment may be made before a Court of Revision consisting of members of the municipal council, notice of such appeal to be given within fourteen days after the return of the assessment roll.

Figure 1. Histogram of the ratios of assessed to estimated values of 246 Ontario farms



As provided by statute, land must be assessed at its actual value, the value of buildings thereon being ascertained separately as that amount by which the value of the land is increased due to the presence of the buildings; the total assessment being the sum of the assessed value of land plus the assessed value of buildings.

## EQUALIZATION

Due to the fact that assessment is made by townships, usually with different assessors for each township, the statutes of the province provide that the real property within each county must be valued at least once in five years by an equalization board consisting of two or more members appointed by the county council. It is also provided that the time for which a valuation shall remain in force may be extended by the county council for a period not exceeding five years. Valuation is made by appraising from 5 to 8% of the different parcels of land in different parts of each municipality and comparing with the valuation of the same properties in the last revised assessment roll of the several municipalities within the county. If the valuation of the county valuators and that of the municipal assessors correspond closely in aggregate, the municipal assessment roll may stand as correct for county purposes. Should there be a material difference between the two, the county valuators are required to make an adjustment by adding or deducting a corresponding percentage to or from the local assessment.

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## THE ACCURACY OF FARM ASSESSMENT

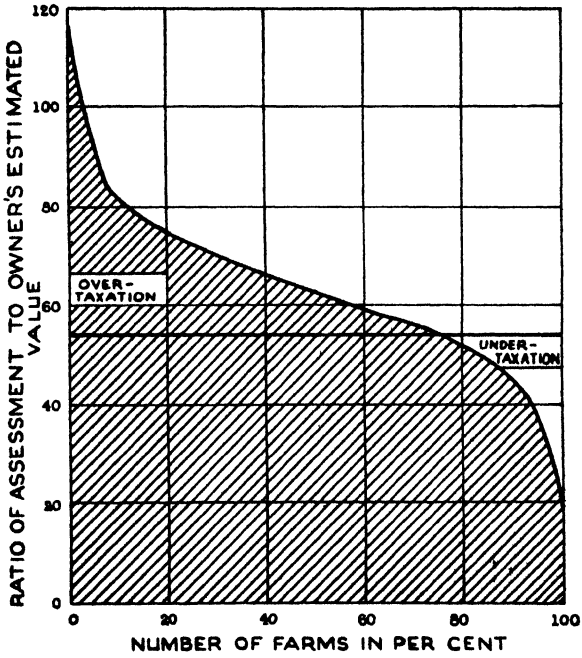
Since an equitable distribution of the burden of farm taxation is dependent, in so far as the individual taxpayer is concerned, on the degree of accuracy by which the various parcels of real estate are assessed, an attempt has been made to study the accuracy of farm assessment in a number of rural municipalities in Ontario.

A number of measures have been evolved for this purpose, the principal one relating to the ratio of assessed to real value of individual parcels of real estate. The greatest difficulty to be encountered in the employment of such a measure is in obtaining a measure of "real value" which is readily acceptable.

Probably the most common measure of real value in studies of assessment is sale value. While there are many points on which the use of sale value in this connection may be recommended, it has certain limitations, chief among which are the effect of forced sales, differences in bargaining power, and ability of the buyer to appraise a farm.

In this study the farm valuation as estimated by the farm operator was taken as the basic measurement of value with which to compare the assessed valuation. While the accuracy of this base depends upon the accuracy of the farmer's estimate and may be open to some criticism, an intelligent farm operator, on account of his intimate contact with his farm and his knowledge of its powers of production, should be in good position to appraise it. The operator's valuation, moreover, in this instance is checked by an experienced farm management investigator. Such an appraisal would be on the basis of productivity which in the final analysis determines the ability to pay. In this connection it must be remembered that irrespective of the fact that property taxes are levied against property and not income, they must ultimately be paid, if at all, from income.

FIGURE 2. DISTRIBUTION OF 246 ONTARIO FARMS ACCORDING TO THE RATE OF ASSESSMENT



The horizontal line represents the average rate of assessment (53 9%). The shaded portion above this line marked "over-taxation" indicates the extent to which certain properties are over-assessed and therefore over-taxed relative to the average of all properties. Similarly the space labeled "under-taxation" shows the extent to which certain properties are under-assessed. Since a larger number of farms are over-assessed than are under-assessed there appears to be a tendency to over-assess low valued farms.

*Procedure.*—The assessed valuations of some 246 farms in nine townships of Ontario for which farm management records were available were obtained from the respective township clerks, and the ratio of the assessed valuation to the value as estimated by the farm operator calculated for each farm.

*Analysis of Results.*—A frequency distribution of these farms by townships according to their ratios of assessed to estimated value is shown in Table 1. A comparison of the average ratios of the several townships indicates considerable variation in the assessment practices of different assessors, the average ratio of assessed to estimated value varying from about 22 to over 70%. It is for the correction of these variations in assessment practices that county equalization is intended.

TABLE 1.—FREQUENCY DISTRIBUTION OF SOME ONTARIO FARMS ON THE BASIS OF THE RATIO OF ASSESSED TO ESTIMATED VALUATION

| Class interval (per cent) | Twp. No. 1 | Twp. No. 2 | Twp. No. 3 | Twp. No. 4 | Twp. No. 5 | Twp. No. 6 | Twp. No. 7 | Twp. No. 8 | Twp. No. 9 | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 15.0 - 19.9 | 1 | — | — | — | — | — | 3 | — | — | 4 |
| 20.0 - 24.9 | — | 1 | — | — | — | 2 | — | — | — | 3 |
| 25.0 - 29.9 | 1 | — | — | — | — | 1 | 2 | — | — | 4 |
| 30.0 - 34.9 | 1 | 1 | 1 | — | — | 1 | 4 | — | — | 8 |
| 35.0 - 39.9 | 2 | — | — | — | — | — | 1 | — | — | 3 |
| 40.0 - 44.9 | 10 | 2 | 2 | 1 | — | 1 | — | — | — | 16 |
| 45.0 - 49.9 | 13 | 8 | 4 | — | — | 1 | — | — | — | 26 |
| 50.0 - 54.9 | 22 | 6 | 6 | — | — | 2 | — | 2 | — | 38 |
| 55.0 - 59.9 | 19 | 12 | 3 | 3 | — | — | — | 1 | 1 | 39 |
| 60.0 - 64.9 | 14 | 14 | 2 | 2 | 5 | 2 | — | 1 | 3 | 43 |
| 65.0 - 69.9 | 4 | 8 | — | — | — | 1 | — | 2 | 2 | 17 |
| 70.0 - 74.9 | 2 | 7 | 1 | 5 | 1 | — | — | 2 | 2 | 20 |
| 75.0 - 79.9 | 1 | 1 | — | 2 | 3 | — | — | 2 | — | 9 |
| 80.0 - 84.9 | 1 | 3 | — | — | 1 | — | — | — | 1 | 6 |
| 85.0 - 89.9 | — | — | — | — | — | — | — | — | — | 0 |
| 90.0 - 94.9 | — | 1 | — | — | — | — | — | — | 1 | 2 |
| 95.0 - 99.9 | 2 | — | — | — | 1 | — | — | — | — | 3 |
| 100.0 -104.9 | 2 | — | — | 1 | 1 | — | — | — | — | 4 |
| 105.0 -109.9 | — | — | — | — | — | — | — | — | — | 0 |
| 110.0 -114.9 | — | — | — | — | — | — | — | — | — | 0 |
| 115.0 -119.9 | — | — | — | — | — | — | 1 | — | — | 1 |
| No. of farms | 95 | 64 | 19 | 14 | 12 | 11 | 11 | 10 | 10 | 246 |
| Average ratio | 52.7 | 57.6 | 50.2 | 65.7 | 72.3 | 43.7 | 21.9 | 63.9 | 68.0 | 53.9 |

On studying the distribution of farms within each township according to the assessment ratio great inaccuracy in the assessment of individual farms, as measured on the basis of estimated value, is noted. The totals for all townships show a range in assessment of from about 15 to over 115%. This is shown graphically in Figure 1. However, since items tend to accumulate about the mean, extremes should be compared with the mean rather than with extremes. A more accurate measure of the variation, therefore, is given by the standard deviation[2], a statistical measure which indicates the scattering of items about their mean. Other things being equal, the smaller the standard deviation, the more closely do the various items cluster about the mean. The standard deviation for all farms was 46.25 indicating great inaccuracy in assessment resulting in over-taxation of some farms and under-taxation of others as compared with the average. This is illustrated graphically in Figure 2. The horizontal line represents the average ratio of the assessed to the estimated actual value of the farms studied which was 53.9%. If all farms were assessed at the average percentage of the actual value, the assessment situation would be represented by this horizontal line. The curved line indicates how widely the actual situation varies from this ideal. The fact that the line is more nearly horizontal in the middle portion of the chart indicates that more of the properties are assessed at the percentage shown in the middle of the vertical scale than are assessed at the extremely low and high percentages. It should be noted that the space marked "under-taxation" below the horizontal line is much smaller in area than that space above the line marked "over-taxation". This indicates that a greater number of farms are over-assessed than are under-assessed, which is explained by the tendency on the part of assessors to over-assess low-valued farms.

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[2] The standard deviation is calculated by finding the difference between each item and the mean, squaring these, totalling, dividing by the number of items, and extracting the square root of the result.

The tendency towards over-assessment of low-valued farms is further indicated in Table 2, in which the farms are grouped according to their estimated value by $10,000 intervals for the purpose of determining the relationship between value and assessment. While farms valued under $10,000 were assessed, on the average, at 61.37% of their estimated value, those valued at from $10,000 up to $20,000 had an average ratio of assessed to estimated value of 54.16%, and those valued at $20,000 and over were assessed at 39 39% of their estimated value. Variation of assessment between individual farms within the groups is greater for the first group than for the second as is indicated by the larger standard deviation and coefficient of variation[3] in the first group. The increase in both measures in the last group is attributable to the small sample. Lower valued farms then, are not only over-assessed as compared with those of higher value but in addition to this their assessment is less accurate.

TABLE 2.—RELATION OF VALUE OF FARM TO ACCURACY OF ASSESSMENT

| Value of farm (dollars) | No. of farms | Average ratio of assessed to estimated value | Standard deviation | Coefficient of variation |
|---|---|---|---|---|
| 0 - 9,999 | 113 | 61.37 | 40.302 | 65.834 |
| 10,000 - 19,999 | 114 | 54.16 | 28.655 | 53.015 |
| 20,000 and over | 19 | 39.39 | 32.130 | 81.573 |
| All farms | 246 | 53.89 | 46.25 | 86.16 |

While it is evident from the foregoing analysis that an individual farm may be assessed anywhere from a fraction of its actual value up to its full value, there is a marked tendency to discriminate against the lower-valued farms by over-assessing them in relation to high-valued farms. It is important, therefore, to study some of

TABLE 3.—RELATION BETWEEN SIZE OF FARM AND ACCURACY OF ASSESSMENT

| Size of farm (acres) | No. of farms | Average ratio of assessed to estimated value | Standard deviation | Coefficient of variation |
|---|---|---|---|---|
| Under 100 | 87 | 50.02 | 31.85 | 63.67 |
| 100 - 200 | 135 | 55.92 | 33.50 | 59.91 |
| 200 and over | 24 | 53.23 | 32.10 | 60.29 |
| All farms | 246 | 53.89 | 46.35 | 86.01 |

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[3] Whereas the standard deviation measures absolute variation, the coefficient of variation, which is the standard deviation expressed as a percentage of the mean ($c/v = \frac{S.D.}{M} \times 100$), measures the relative variation of different series.

the factors affecting value of property and to determine the extent to which these factors are considered by the assessor.

*Size of Farm.*—In an attempt to determine the influence of the number of acres in the farm on the assessment, the farms were grouped according to size and the average ratio of assessed to estimated value calculated for each group (Table 3). Since the assessment ratio is essentially the same for all three groups, there is no apparent tendency on the part of the assessor towards giving undue weight to the number of acres in the farm in making an assessment as compared with that of the owner.

*Value per Acre.*—In order to measure the extent to which assessors are influenced by value per acre, the farms were divided into four groups on this basis, the average ratio of assessed to estimated value being determined for each group. The results, which are presented in Table 4, indicate that farms having a low "per acre" value are over-assessed as compared with those having a high "per acre" value. That is, the assessor apparently does not give sufficient consideration to the "quality" aspect of a farm in making his assessment, with the result that the more productive farm is often assessed at a lower rate than one the productivity of which is relatively low.

*Buildings and Improvements.*—The average ratios of assessed to estimated value of farms in the groups in which a relatively small proportion of the total value is in buildings are distinctly smaller than in the groups where buildings make up a large proportion of the farm value (Table 5). It would seem then, that in valuing a farm the assessor gives undue weight to buildings with the result that a poor farm which is well equipped in this respect may be assessed much higher than a more productive farm having less pretentious buildings

TABLE 4.—RELATION BETWEEN THE "PER ACRE" VALUE OF REAL ESTATE AND ACCURACY OF ASSESSMENT

| Estimated value of real estate per acre (dollars) | No. of farms | Average ratio of assessed to estimated value | Standard deviation | Coefficient of variation |
|---|---|---|---|---|
| Under 75 | 53 | 67.79 | 37.70 | 55.61 |
| 75 - 100 | 83 | 58.73 | 22 58 | 38.45 |
| 100 - 125 | 85 | 50 86 | 32.02 | 62.95 |
| 125 and over | 27 | 33.82 | 20.72 | 61.28 |
| All farms | 246 | 53.89 | 46.35 | 86.01 |

## SUMMARY

The preceding analysis of assessment has indicated that notwithstanding the fact that the law provides that "land shall be assessed at its actual value", the common practice of assessors is to assess property on a percentage basis. In this connection the provision of an equalization board may in itself be considered an admission that assessment is not made on the basis of actual value. It has been demonstrated also that two parcels of farm real estate in the same general locality on which the respective farm operators have placed the same value may be assessed at valuations which differ widely. These differences resulting from inaccuracy of assessment, while significant for all properties, are greater in the lower value groups. A marked tendency to over-assess low-valued properties on the basis of their estimated valuations as compared with high-valued properties is also apparent. This was found to be due, in part at least, to the inability of assessors to give sufficient consideration to the "quality" aspect or "per acre" value of a farm together with the tendency to give undue weight to the value of buildings in assessing a farm.

TABLE 5.—RELATION BETWEEN THE PROPORTION WHICH VALUE OF BUILDINGS IS OF VALUE OF REAL ESTATE AND ACCURACY OF ASSESSMENT

| Value of buildings expressed as a percentage of value of real estate | No. of farms | Average ratio of assessed to estimated value | Standard deviation | Coefficient of variation |
|---|---|---|---|---|
| Under 30 | 12 | 34.1 | 26.68 | 78.22 |
| 30 - 40 | 29 | 52.6 | 19.95 | 37.93 |
| 40 - 50 | 41 | 55.5 | 22.52 | 40.57 |
| 50 - 60 | 70 | 53.0 | 31.70 | 59.81 |
| 60 - 70 | 54 | 58.2 | 23.55 | 40.46 |
| 70 - 80 | 20 | 60.1 | 20.35 | 33.86 |
| 80 and over | 20 | 65.1 | 21.75 | 33.41 |
| Totals | 246 | 53.9 | 46.25 | 86.16 |

It should be mentioned that it is not intended that the assessors should be held personally responsible for the inaccurate assessment of farm property but it is felt rather that this is due more to inherent weaknesses of the assessment system which must necessarily be corrected before an adequate appraisal of the present system of property taxation can be made.

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A review of the work of the European Commercial Representative of the Fruit Growers' Association of Ontario during the past five seasons, 1929 to 1934 indicates that a very satisfactory development of overseas markets for Ontario fruit has taken place. Andrew Fulton, who is in charge of the London agency for the above organization states in his report that apple exports from Ontario rose from an average of 70,000 barrels for 1920-29 to 375,000 barrels in the 1933 season. Sales have increased from $70,000 in 1929-30 to $1,235,000 in 1933-34. Large savings to shippers have been made in selling charges, amounting to $35 to $70 per car load and totalling $110,000 per annum. This has been accomplished largely through the policy of the Ontario Fruit Growers' Association in assisting growers to standardize their product and by establishing packing houses and cold storage plants. The London representative has done much to develop marketing by pointing out weaknesses in the product and establishing contacts with the trade for standard brands.

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Farm economic research in Saskatchewan has been in progress since 1925 under the direction of Dr. Wm. Allen of the University of Saskatchewan. Since 1930, studies of individual farm businesses have provided considerable information on farm indebtedness. From 1930 to 1933 inclusive, records were obtained from 1,323 farms situated in representative districts of Saskatchewan. In 1930, in the northwest park belt, the farming district around Turtleford was studied, and on the heavy land of the west-central portion of the prairie plains, the district of Kindersley was selected. Indebtedness per acre of crop land for these two areas was found to be $11.32 and $10.59 respectively. Similar figures for districts studied in 1931 were as follows: Davidson $10.68, Maple Creek $3.66, and Richmond $3.53. For 1932 the figures were Rosemount, Redford $14.42, Scott $24.29, Wellington $13.92 and Brokenshell $7.07. The 1933 study revealed that indebtedness per crop acre was $19.12 in the Grenfell and Wolseley districts, $17.91 at Balcarres and Indian Head, and $16.36 in the Neudorf and Lemberg districts. The difficulties of the recent years have prevented farmers meeting their obligations and despite reduced costs of operation and curtailed living expenses indebtedness has generally increased.

# THE WHEAT SITUATION IN FRANCE

According to an Associated Press report (dated May 25) France has left the ranks of wheat importing countries to join those of exporters. Prior to 1929, France did not produce sufficient wheat to meet her domestic requirements, except in years when exceptionally large crops were harvested. Large crops were grown in 1929, 1932 and again in 1933, so that a surplus of wheat has been built up. Commencing in 1929, several forms of control measures were adopted by the Government in order to protect French farmers.

In pre-war years France produced very large crops. The 1890 crop amounted to 330 million bushels or equivalent to the production of 1932.[1] In the five-year period from 1909 to 1913, production averaged 317 million bushels per annum. From 1928 to 1932, it was 290 million bushels or about 27 million bushels under the pre-war average. France has not reached her pre-war average acreage of wheat which amounted to 16.5 million acres. In 1933 acreage was 13,358,000 and it has not changed materially since 1920.

Domestic requirements of wheat in France average 325 million bushels per annum. Prior to 1929, an amount averaging 50 million bushels had to be imported each year.

Beginning in 1929, France has imposed several regulations to control the domestic wheat market. In May, 1929, the duty on wheat was increased from 37 to 53 cents a bushel and further raised to 85 cents in June, 1930. The general tariff now stands at $1.70 per bushel applicable to countries with which commercial treaties have not been made. It has since been further increased.

A domestic milling quota was established in December, 1929, to provide for the use of 97% of the domestic wheat in French mills. Since then, the extraction ratio has been lowered to 66%. Authorities considered that a low extraction ratio would increase wheat consumption. It is stated that bakers for a time utilized low grade flour which they were not supposed to buy, so that in January, 1934,[2] further regulations were imposed on flour extraction. Millers are now forbidden to sell such flour for home consumption and bakers are forbidden to hold it in store. It is also illegal to buy, sell, offer or utilize flour for bread-making at a price not corresponding to a price to be determined for each province.

A subsidized storage decree, based on a law of April, 1930, was issued in October, 1932.[3] The October decree widened the powers of the original law, providing for the withdrawal of 22 million bushels from the market in 1932, this to be carried into the next season. The principle of the wheat subsidized storage scheme is that producers, by holding part of the current crop, will receive the so-called "conservation or carry-over premium" at the expiration of the storage contract for the wheat held off the market. The government advances 80% of the values of the wheat stored to the farmers and supplies long-term credits at 2% to cover two-thirds of the cost of storage facilities In 1930-31, about 1.5 million bushels were stored, in 1931-32, about 3 67 million bushels and in 1932-33, it was anticipated that 7 to 18 million bushels would be handled in this way.

In July, 1933, the government inaugurated a price fixing schedule, fixing the price of wheat at $2.05 a bushel (U.S. exchange). This price was advanced to 2.7 cents per month. On the whole it has been a nominal market price. The minimum price was evaded by many millers and those who did adhere to it lost money because they could not compete with the more cheaply produced flour. The provisions mentioned above should prevent the occurrence of this in the future. An amendment to this measure was passed in December, 1933, extending the minimum prices to any surplus resulting from the 1933 crop. This was done to prevent distress sales and to permit farmers to hold their crop until after the end of the season. Another provision of the amendment prohibits the growing of a grain crop after grain in any crop rotation. This will likely limit acreage somewhat.

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[1] Monthly Review of the Wheat Situation, Dominion Bureau of Statistics, January 24, 1933.
[2] Foreign Crops and Markets, Vol. 28. No. 10.
[3] Foreign Crops and Markets, Vol. 25. No. 21.

A sales tax of 3 francs per quintal on all wheat sold has been instituted to help raise revenue for market support. The farmer also pays a commission to the local grain merchant, the total official deduction, including the tax, amounting to about 9 cents per bushel.

In 1933, France attempted to remove 18 million bushels of wheat from the domestic market by granting an export bonus of about $1.43 per bushel. Only 1.8 million bushels were removed as the bounty was found to be insufficient to make French wheat cheap enough for competition on the world market. In December, 1933, the French Government ceased to issue export licences.[4]

## ECONOMIC LITERATURE

Coats, R. H., Marshall, H., and Greenway, H. F. Wholesale Price Index Numbers of Canadian Farm Products. Internal Trade Branch, Dominion Bureau of Statistics, Ottawa, mimeo. 15 pp.

This monograph provides a record of monthly and annual movements in wholesale prices of Canadian farm products from 1890 to 1933. No such data have been available previously for years prior to 1913, while annual indexes only were available for the years 1913 to 1918 inclusive. The authors include brief notes on the growth of agricultural production, the economic history of the period and the problems of index number construction in addition to the outline of price movements.

Canadian indexes bear out the widely accepted premise that farm products prices react more quickly to broad influences than do those of commodities in general. From the beginning of the war until 1920, the farm products index was steadily above the index of all commodities, and subsequently its decline was more precipitate. From 1929 to 1932, when practically all prices were falling, prices of farm products dropped much more rapidly than the average of all commodities, and this has given rise to an unusually serious dislocation in purchas ng power between the agricultural community and other economic groups.

Field crops exert a dominant influence upon the movement of price indexes of Canada farm products. On numerous occasions field products prices have soared, but these movements as a rule have been of only a few months' duration. The wide fluctuations prevalent in the field product group are attributable chiefly to the occasional precipitous fluctuations of grain and potato prices. Changes of 20% to 30% within one year for these items have been common.

The stability of yearly average price index numbers for animal products shows up in contrast to the wide swings of field product indexes. Such averages had, however, regular and pronounced seasonal movements of considerable magnitude. Milk prices have exerted a considerable influence in the animal products group.

Per capita consumption of beef according to the Agricultural Branch, Dominion Bureau of Statistics, was 65.77 pounds in 1930 and declined in 1931 to 57.92. A further reduction to 56.02 pounds took place in 1932 whereas in 1933 there was a very slight increase to 56.09.

Consumption of pork was 72.92 pounds in 1930 and increased to 85.61 in 1932 during the past year, however, there was a marked reduction to 74.58 pounds.

Consumption of butter has remained almost constant, being reported as 30.59 pounds in 1930; 30.76 in 1931; 30.49 in 1932; and 30.04 in 1933.

The consumption of eggs has declined from 24.92 dozens in 1930 to 21,45 dozens in 1933.

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[4] Foreign Crops and Markets, Vol. 28. No. 10.

## NOTES

According to the New Zealand Journal of Agriculture, April 20, 1934, the total value of farm production in New Zealand was £52,500,000 in 1932-33, as compared with £50,400,000 in 1931-32 and £83,400,000 in 1928-29. Agricultural production (crops) totalled £8,900,000 in 1932-33, an increase of 11% over the previous crop year. The value of pastoral production was £20,400,000, an increase of 5.7% over the exceptionally low figure recorded in 1931-32. The value of dairy production remained practically the same.

Crop yields, particularly wheat and oats were higher in 1932-33 than in 1931-32. Wool production increased while production and exports of beef, lamb and pork were in excess of the totals for the preceding year. The volume of butter and cheese production increased but the fall in prices counteracted a rise in the total value of these products.

The Crop Reporting Board of the United States Department of Agriculture issues a monthly bulletin on prices received by farmers at local markets. For May 15, 1934 the price per bushel for the following crops was: oats 32.7 cents, barley 42.2, wheat 69.5, rye 51.9, flaxseed 163.7, potatoes 73.7, and apples 113.7 cents. The price received per ton for hay was \$8.94 Live stock prices per 100 pounds were as follows: hogs \$3.17, beef cattle \$4.13, veal calves \$4.83, lambs \$6.95 and sheep \$3.54. Eggs brought 13.3 cents per dozen, butter 21.6 cents per pound and butterfat 21 5 cents per pound. Farmers received \$1.45 per hundredweight for whole milk (wholesale), and 9.1 cents per quart for whole milk (retail).

The sixth annual meeting of the Canadian Society of Agricultural Economics was held at Macdonald College, Ste. Anne de Bellevue, June 25–27. The program included the following papers: Some Farm Tax Problems in Ontario; The Preparation of Outlook Material; The Use of Outlook Material in Planning a Farm Program; Farm Management Research; The Peoples' Banks in Quebec; The Census of Agriculture; The Bankground of Present Legislation to Regulate Marketing: The Natural Products Marketing Act; Marketing of Australian Agricultural Products through federal and State Boards; An Appraisal of the Program Initiated under the Agricultural Adjustment Act in the United States; and Possibilities for Export of Canadian Agricultural Products.

Two co-operative wholesale purchasing societies established within the last five years in Manitoba and Saskatchewan have grown into business operators of considerable size. These wholesale companies handle bulk commodities such as gasoline, lubricating oils, binder twine, coal, lumber, fence wire and certain household supplies. The commodities are purchased in car lot quantities and distributed to member societies on a commission basis.

The Manitoba Co-operative Wholesale Limited served 53 local co-operative associations in 1933 Its business during the past year slightly exceeded a quarter of a million dollars. The Saskatchewan Co-operative Wholesale Society Limited was the purchasing agent for 36 local co-operative organizations. Its volume of business in 1933 was just over \$300,000. Both companies ended a successful year with a surplus and turned back nearly \$3,000 in patronage dividends to their shareholder members.

*Continued from page 22—*

in that it is excessive or results in undue enhancement of prices or otherwise restrains or injures trade or commerce in the natural or regulated product.

Any person who charges, receives, or attempts to receive any spread which is excessive shall be guilty of an indictable offence and liable to a fine or imprisonment. Consideration of the language used indicates that it is not the intention of Parliament that a committee appointed under the Act shall unnecessarily scrutinize trade and commerce or interfere with recognized margins and reasonable profits. It is the intention, however, to prevent unreasonable spreads and excessive profits. In this respect both producer and consumer are offered a measure of protection.

SCIENTIFIC AGRICULTURE

Vol. XIV AUGUST, 1934 No. 12

# STUDIES ON VIM OAT FEED. 2. THE DIGESTIBILITY OF OAT HULLS

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[Received for publication March 26, 1934]

Under the Feeding Stuffs Act of Canada (*1*) six grades are provided for oat products, namely, Oat Groats, Oat Hulls, Oat Middlings, Oat Shorts, Clipped Oat By-product and Oat Feed.

Oat Hulls and Oat Feed are defined, respectively, as follows:

"Oat Hulls are the outer covering of the oat, and any by-products obtained in the milling of rolled oats from clean oats, and containing 28 per cent or more of fibre, shall be designated as 'oat hulls'."

"Oat Feed consists of offal obtained in the milling of rolled oats from clean oats, and containing less than 28 per cent of fibre. It must include not less than the mill-run of oat middlings and not more than the mill-run of oat hulls".

The object of the present investigation is to compare the feeding values of representatives of each of these two grades upon the basis of digestibility trials.

The digestibility of Vim Oat Feed, together with an estimate of its feeding value based upon this digestibility, was published in a previous communication (*5*). In order to make a comparison between the value of oat hulls and the value of Vim Oat Feed, it was necessary to repeat with oat hulls essentially the same procedure that had been adopted in the case of the Vim Oat Feed.

The feeds used differed in physical make-up. The Vim Oat Feed was purchased in the form of finely ground meal while the oat hulls, though put through a hammer mill, were much coarser. In fact, it was not found possible to duplicate, in the oat hulls, the condition of the Oat Feed and the former still contained a large proportion of small, broken hull particles. The comparison in value, therefore, was made between finely ground Vim Oat Feed and coarsely ground oat hulls. The composition of the feeding stuffs used is given in Appendix Table 11.

Four grade Shorthorn steers were used in the experiments, with an initial weight averaging 1010 pounds and a final weight averaging 1181 pounds. Their age at the commencement of the trials was a few months over two years. The trials began in August, 1932, and were concluded in June, 1933. The steers were numbered 84387J, 84381J, 84424J and 84422J.

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The digestion trials consisted of a fourteen-day preliminary period followed by a collection period of twelve days. The collection period was divided into three sub-periods during each of which the feed and excrement were composited, sampled and analyzed. The daily ration was fed in two equal quantities at 5.30 a.m. and 4.30 p.m. The animals were watered by hand one hour after each feeding.

The digestion trials were conducted in the following order:

(1) Experiment AN 13–1: Digestibility of a basal ration of mixed clover and grass hay.
(2) Experiment AN 13–2: Digestibility of a mixed ration of the above hay ration and oat hulls.
(3) Experiment AN 13–3: Digestibility of oat hulls, fed alone.
(4) Experiment AN 13–4: Digestibility of a basal ration of mixed clover and grass hay.
(5) Experiment AN 13–5: Digestibility of a mixed ration of the above hay and oat hulls.
(6) Experiment AN 7–2: Digestibility of Vim Oat Feed fed alone.

All the necessary data pertaining to the digestion trials are given in Tables 11 to 17 in the appendix. A summary of the coefficients of digestibility is given in Tables 1 to 6 which follow.

TABLE 1.—COEFFICIENTS OF DIGESTIBILITY OF THE BASAL RATION OF CLOVER AND MIXED HAY. DAILY RATION—7.5 KILOS

| — | Experiment AN 13–1 | | | | | Experiment AN 13–4 | | |
|---|---|---|---|---|---|---|---|---|
| | Animal 84387J | Animal 84381J | Animal 84424J | Animal 84422J | Average | Animal 84387J | Animal 84381J | Average |
| Dry matter | 59.8 | 59.4 | 59.6 | 59.7 | 59.6 | 59.7 | 59.1 | 59.4 |
| Organic matter | 63.0 | 62.9 | 63.1 | 63.6 | 63.2 | 61.1 | 60.5 | 60.8 |
| Nitrogen | 59.4 | 61.2 | 58.8 | 61.2 | 60.2 | 62.3 | 63.4 | 62.9 |
| Ether extract | 29.9 | 23.3 | 29.4 | 22.8 | 26.4 | 41.6 | 41.8 | 41.7 |
| Crude fibre | 57.0 | 57.2 | 56.2 | 60.0 | 57.6 | 54.4 | 52.9 | 53.7 |
| N-free extract | 68.8 | 68.5 | 69.5 | 68.3 | 68.8 | 65.8 | 65.6 | 65.7 |

TABLE 2.—COEFFICIENTS OF DIGESTIBILITY OF MIXED RATION OF HAY AND OAT HULLS

| — | Experiment AN 13–2 | | | | Experiment AN 13–5 | | |
|---|---|---|---|---|---|---|---|
| | Hay —5.5 kg.<br>Hulls—2.5 kg. | | Hay —5.5 kg.<br>Hulls—5.0 kg. | | Hay —5.5 kilos<br>Oat Hulls—2.5 kilos | | |
| | Animal 84387J | Animal 84381J | Animal 84424J | Animal 84422J | Animal 84387J | Animal 84381J | Animal 84424J |
| Dry matter | 52.4 | 49.2 | 43.7 | 44.2 | 49.9 | 47.4 | 47.3 |
| Organic matter | 55.2 | 51.8 | 46.7 | 46.8 | 51.2 | 49.0 | 49.1 |
| Nitrogen | 54.6 | 53.8 | 49.1 | 51.4 | 58.4 | 57.9 | 56.0 |
| Ether extract | 34.0 | 38.5 | 35.4 | 30.3 | 44.3 | 35.3 | 37.4 |
| Crude fibre | 53.6 | 47.3 | 44.3 | 45.1 | 47.0 | 45.1 | 44.7 |
| N-free extract | 56.6 | 54.4 | 48.0 | 47.8 | 52.5 | 50.4 | 51.0 |

TABLE 3.—CALCULATED COEFFICIENTS OF DIGESTIBILITY OF OAT HULLS

| — | Calculated from Experiment AN 13–2 | | | | Calculated from Experiment AN 13–5 | | | Mean | Co-efficient of variation | Standard Error |
|---|---|---|---|---|---|---|---|---|---|---|
| | Animal 84387J | Animal 84381J | Animal 84424J | Animal 84422J | Animal 84387J | Animal 84381J | Animal 84424J | | | |
| Dry matter | 36.6 | 26.4 | 26.5 | 27.5 | 29.1 | 21.1 | 20.8 | 26.9 | 19.8 | ±2.02 |
| Organic matter | 38.4 | 27.7 | 29.4 | 29.6 | 30.4 | 23.6 | 23.9 | 29.0 | 17.1 | ±1.88 |
| Nitrogen | — | — | — | — | — | — | — | — | — | — |
| Ether extract | — | — | 75.5 | 47.9 | — | — | — | — | — | — |
| Crude fibre | 46.3 | 28.4 | 32.2 | 33.7 | 34.2 | 28.6 | 27.7 | 33.0 | 19.2 | ±2.43 |
| N-free extract | 33.8 | 27.4 | 28.5 | 28.2 | 28.0 | 21.7 | 23.5 | 27.3 | 14.2 | ±1.47 |

TABLE 4.—CALCULATED COEFFICIENTS OF DIGESTIBILITY OF OAT HULLS OMITTING ANIMAL NO. 84387J

| — | Mean | Coefficient of variation | Standard Error |
|---|---|---|---|
| Dry matter | 24.5 | 13.2 | ±1.45 |
| Organic matter | 26.8 | 10.9 | ±1.30 |
| Nitrogen | — | — | — |
| Ether extract | — | — | — |
| Crude fibre | 30.1 | 8.8 | ±1.19 |
| N-free extract | 25.8 | 11.9 | ±1.37 |

In regard to Tables 3 and 4, animal 84387J showed a peculiar idiosyncrasy in the digestion trials of this investigation as well as in other investigations conducted during the year. The coefficients of digestibility of any given single feed when determined with this animal always agreed closely with those determined on the other animals. In the case of the mixed rations, however, the coefficients of digestibility as determined with animal 84387J were always much higher than those of the others. This increase corresponded with an increase in the digestibility of the crude fibre and may indicate a more active fermentation in the digestive tract. Accordingly, for comparison with Vim Oat Feed, all calculations have been made both including and excluding the results of animal 84387J.

TABLE 5.—COEFFICIENTS OF DIGESTIBILITY OF OAT HULLS WHEN FED AS THE SOLE FEED IN A RATION. DAILY RATION—7.5 KILOS

| — | Animal 84387J | Animal 84381J | Animal 84424J | Animal 84422J | Mean | Co-efficient of variation | Standard Error of mean |
|---|---|---|---|---|---|---|---|
| Dry matter | 39.2 | 38.7 | 40.8 | 42.3 | 40.3 | 4.06 | ±0.82 |
| Organic matter | 41.5 | 40.5 | 42.5 | 44.4 | 42.2 | 3.95 | ±0.83 |
| Ether extract | 44.2 | 51.6 | 49.2 | 41.0 | 46.5 | 10.30 | ±2.40 |
| Crude fibre | 50.8 | 48.7 | 51.4 | 51.9 | 50.7 | 2.77 | ±0.70 |
| N-free extract | 37.1 | 36.1 | 38.3 | 40.8 | 38.1 | 5.32 | ±1.01 |

In Table 6, to the results obtained in this investigation when Vim Oat Feed was fed alone, have been added the results obtained in a similar manner during the previous year's work (*5*).

TABLE 6.—COEFFICIENTS OF DIGESTIBILITY OF VIM OAT FEED WHEN FED AS THE SOLE FEED IN A RATION

| — | 1932 | | 1933 | | Mean | Co-efficient of variation | Standard Error of mean |
|---|---|---|---|---|---|---|---|
| | Experiment AN 7-1 | | Experiment AN 7-2 | | | | |
| | Animal 84387J | Animal 84381J | Animal 84424J | Animal 84422J | | | |
| Dry matter | 33.5 | 33.5 | 37.5 | 38.9 | 35.9 | 7.73 | ±1.39 |
| Organic matter | 34.5 | 35.2 | 39.6 | 41.0 | 37.6 | 8.54 | ±1.61 |
| Nitrogen | 45.7 | 40.3 | 50.5 | 53.6 | 47.5 | 12.23 | ±2.91 |
| Ether extract | 66.3 | 66.9 | 74.5 | 71.4 | 69.8 | 5.57 | ±1.94 |
| Crude fibre | 32.7 | 33.5 | 36 2 | 36.6 | 34.8 | 5.58 | ±0.97 |
| N-free extract | 33.2 | 34.3 | 38.6 | 40.8 | 36.7 | 9.75 | ±1.79 |

## COMPARISON OF THE DIGESTIBILITY OF OAT HULLS WITH THAT OF VIM OAT FEED

The results given in Tables 3, 4, 5 and 6 are summarized in Tables 7 and 8. The values for Vim Oat Feed given in Table 7 were taken from the previous publication (*5*).

From an examination of Table 7, it will be seen that the coefficients of digestibility of the dry matter and the organic matter were similar for both the oat hulls and the Vim Oat Feed. The digestibility of the crude fibre of the hulls was significantly[4] greater than that of the Vim Oat Feed, while the digestibility of the nitrogen-free extract tended to be lower. Figures for the digestibility of the nitrogen are not included since it was not possible to determine these values for the oat hulls. The coefficient

TABLE 7.—COEFFICIENTS OF DIGESTIBILITY OF OAT HULLS AND VIM OAT FEED CALCULATED FROM A MIXTURE OF EACH WITH HAY

| — | | Dry matter | Organic matter | Crude fibre | Nitrogen-Free extract |
|---|---|---|---|---|---|
| Vim Oat Feed | Mean (four values) | 25.7 | 27.0 | 18.4 | 30.0 |
| | Coefficient of variation | 8.45 | 8.19 | 13.70 | 7.21 |
| | Standard Error of mean | ±1.09 | ±1.11 | ±1.26 | ±1.08 |
| Oat Hulls, including animal 84387J | Mean (seven values) | 26.9 | 29.0 | 33.0 | 27.3 |
| | Coefficient of variation | 19.8 | 17.1 | 19.5 | 14.2 |
| | Standard Error of mean | ±2.02 | ±1.88 | ±2.43 | ±1.47 |
| Oat Hulls, omitting animal 84387J | Mean (five values) | 24.5 | 26.8 | 30.1 | 25.8 |
| | Coefficient of variation | 13.2 | 10.9 | 8.8 | 11.9 |
| | Standard Error of mean | ±1.45 | ±1.30 | ±1.19 | ±1.37 |

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[4] "Significance of differences of mean of small samples" from Fisher's "Statistical Methods for Research Workers", page 109 (1925), was used to determine the significance of the differences in this publication.

of digestibility of the nitrogen for Vim Oat Feed had been found previously to be 52%.

In spite of the difference in digestibility of the crude fibre contents of the two feeds, there was no difference in the digestibility of the dry matter contents. This was due to the summation of two factors, the mathematical difference in the digestibility of the nitrogen-free extract added to the small amount of digestible protein in Vim Oat Feed.

As an explanation for the reciprocal condition existing in the case of the coefficients of digestibility of crude fibre and nitrogen-free extract, two reasons may be advanced. In the first place, some material determined as "crude fibre" in the analysis of a feed may, in the analysis of the feces be removed by the acid-alkali treatment and reported as "nitrogen-free extract".[5] The quantity of such material may have been greater in the case of the oat hulls than with the Vim Oat Feed. In the second place, the oat hulls, owing to their more bulky condition may have been retained for a greater length of time in the reticulo-rumen cavities. Under this circumstance, they would be subjected to a greater fermentation which may have influenced the digestibility of the crude fibre.

From an examination of Table 8, it will be seen that the relationship of the digestibility of the oat hulls to the Vim Oat Feed when each was fed as the sole ration was qualitatively the same as that when each had been fed in a mixed ration with hay. The coefficient of digestibility of the crude fibre of the oat hulls as before was significantly higher than that of the Vim Oat Feed. The differences between the digestibilities of the organic matter and the nitrogen-free extract, respectively, for the two feeds were, on the other hand, not significant. In the case of the dry matter, the odds are about 20 to 1, that the difference is significant.

TABLE 8.—COEFFICIENTS OF DIGESTIBILITY OF VIM OAT FEED AND OAT HULLS WHEN FED ALONE

| — | | Dry matter | Organic matter | Crude fibre | Nitrogen-free extract |
|---|---|---|---|---|---|
| Vim Oat Feed | Mean (four values) | 35.9 | 37.6 | 34.8 | 36.7 |
| | Coefficient of variation | 7.73 | 8.54 | 5.58 | 9.75 |
| | Standard Error of mean | ±1.39 | ±1.61 | ±0.97 | ±1.79 |
| Oat hulls | Mean (four values) | 40.3 | 42.2 | 50.7 | 38.1 |
| | Coefficient of variation | 4.06 | 3 95 | 2.77 | 5.32 |
| | Standard Error of mean | ±0.82 | ±0.83 | ±0.70 | ±1.01 |

It will be noticed in Table 8 that the coefficients of variation are larger for the results with the Vim Oat Feed than with the oat hulls. These values for the Vim Oat Feed were obtained from different shipments in different seasons and different experiments. The values for the oat hulls, on the other hand were determined with one shipment and in one experiment only. The values obtained for Vim Oat Feed with animals 84424J and 84422J (see Table 6) correspond to the values obtained with the oat hulls in point of shipment and time of experiment. They also closely approach those for oat hulls in magnitude with the exception of the crude fibre, the digestibility of which is still considerably lower for the Vim Oat Feed than for the oat hulls.

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[5] This same viewpoint has been expressed by Mitchell in a recent publication (2).

## COMPARISON OF OAT HULLS AND VIM OAT FEED ON THE BASIS OF THEIR CONTENT IN DIGESTIBLE NUTRIENTS

In Table 9, a comparison is made between the contents of digestible nutrients in oat hulls and in Vim Oat Feed, the results being calculated to the moisture-free basis. The values given are averages of calculations made on each individual digestion trial. In the case of oat hulls, the deviations are the result not only of the variations in the coefficients of digestibility but also of the difference in chemical composition between the two shipments used.

To express the total digestible nutrients in one single entity and at the same time allow for the greater value of the protein, the method of Petersen (*3*) as applied to Canadian conditions by Stothart (*4*) was used. The results were expressed in terms of dollars and cents per ton. The assumption was made, of course, that digestible carbohydrates have the same value per unit in both the hulls and the oat feed.

TABLE 9.—DIGESTIBLE NUTRIENTS IN POUNDS PER 100 POUNDS OF FEED AND MONEY VALUES IN DOLLARS PER TON. CALCULATED FROM THE RESULTS OF DIGESTION TRIALS WHEN THE FEEDING STUFFS UNDER CONSIDERATION WERE FED WITH HAY. EXPRESSED ON MOISTURE-FREE BASIS

| — | Oat Hulls calculated from experiments AN 13-2 and AN 13-5, including animal 84387J | | | Oat Hulls calculated from experiments AN 13-2 and AN 13-5, omitting animal 84387J | | | Vim Oat Feed calculated from experiment 3 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Mean of seven values | Co-efficient of vari-ation | Stand-ard Error of mean | Mean of five values | Co-efficient of vari-ation | Stand-ard Error of mean | Mean of four values | Co-efficient of vari-ation | Stand-ard Error of mean |
| Digestible crude protein | — | — | — | — | — | — | 2.38 | 4.90 | ±0.06 |
| Digestible crude fibre | 11.75 | 18.77 | ±0.83 | 10.71 | 7.79 | ±0.37 | 5.39 | 13.79 | ±0.37 |
| Digestible N-free extract | 15.30 | 15.23 | ±0.88 | 14.51 | 13 21 | ±0.86 | 17.46 | 7.20 | ±0.63 |
| Total digestible nutrients* | 27.27 | 16.08 | ±1.66 | 25.52 | 11 32 | ±1.29 | 25.59 | 8.22 | ±1.05 |
| Value when barley is $23.00 and oil cake is $32.00 | $6.53 | 16.10 | ±0.40 | $6.11 | 11.33 | ±0.31 | $7.18 | 7.49 | ±0.27 |
| Value when barley is $23.00 and oil cake is $42.00 | $5.09 | 16.15 | ±0 31 | $4.76 | 11.23 | ±0.24 | $6.94 | 6.84 | ±0.24 |
| Value when barley is $33.00 and oil cake is $32.00 | $11.39 | 16.05 | ±0.69 | $10.66 | 11.23 | ±0.54 | $10.65 | 8.24 | ±0.44 |

* That the average values for the total digestible nutrients do not agree with the values calculated from the average values of the individual nutrients is due to the fact that in some cases values for digestible ether extract were obtained. These values were included in the calculations of the total digestible nutrients for those cases.

There is no significant difference between the total digestible nutrients per 100 pounds in oat hulls and Vim Oat Feed. The oat hulls contain a significantly higher quantity of digestible crude fibre, whereas the oat feed contains a higher content of digestible nitrogen-free extract. In this latter case, the difference is not significant when animal 84387J is included. When this animal is omitted, however, the odds are approximately 30 : 1 that the difference is significant.

The values per ton are only significantly different when barley is quoted at $23.00 per ton and oil cake $42.00. This is due to the high price accredited to digestible protein, namely, 5.48 cents per pound as compared with 0.933 cents for the carbohydrates. The oat feed is credited with 2.38 lbs. digestible crude protein per 100 lbs., whereas it was not possible to estimate the digestible protein in oat hulls. This does not imply of course that the latter is necessarily devoid of digestible protein.

Similar calculations are presented in Table 10 for the condition where the feeds were fed alone in the ration. In this case the deviations observed in the values for the Oat Feed are the result of both the variations in the individual coefficients of digestibility and the difference in chemical composition between the two lots of feed used.

From an examination of Table 10, it will be seen that the two feeds are similar, the only significant difference being in the case of the digestible crude fibre, which is higher in the oat hulls than in the Vim Oat Feed. As before, with barley at $23.00 per ton and oil cake at $42.00, the Vim Oat Feed tends to have a higher value.

TABLE 10.—DIGESTIBLE NUTRIENTS PER 100 POUNDS OF FEEDING STUFF AND VALUE PER TON AS CALCULATED FROM DIGESTION TRIALS IN WHICH THE FEEDS WERE FED ALONE IN THE RATION, EXPRESSED ON THE DRY MATTER BASIS

| — | Oat Hulls, calculated from experiment AN 13–3 | | | Vim Oat Feed, calculated from experiment AN 7–1 and 7–2 | | |
|---|---|---|---|---|---|---|
| | Mean of four values | Co-efficient of variation | Standard Error of mean | Mean of four values | Co-efficient of variation | Standard Error of mean |
| Digestible crude protein | — | — | — | 2.41 | 32.12 | ±0.39 |
| Digestible ether extract | 0.26 | 10.17 | ±0.01 | 1.41 | 13.42 | ±0.10 |
| Digestible crude fibre | 18.16 | 2.80 | ±0.25 | 11.13 | 4.13 | ±0.23 |
| Digestible N-free extract | 21.34 | 5.35 | ±0.57 | 19.85 | 7.17 | ±0.71 |
| Total digestible nutrients | 40.08 | 3.86 | ±0.77 | 36.56 | 8.25 | ±1.51 |
| Value when barley is $23.00 and oil cake is $32.00 | $9 60 | 3.89 | ±0.19 | $9.82 | 10.71 | ±0.53 |
| Value when barley is $23.00 and oil cake is $42.00 | $7.48 | 3.87 | ±0.14 | $9.01 | 14.01 | ±0.64 |
| Value when barley is $33.00 and oil cake is $32.00 | $16.76 | 3 85 | ±0.32 | $15.22 | 8.22 | ±0.64 |

## SUMMARY AND CONCLUSIONS

Digestibility trials were undertaken with grade Shorthorn steers upon oat hulls, coarsely ground, with and without a basal ration of hay and upon Vim Oat Feed, finely ground, when fed alone in the ration. From the results of these trials, the coefficients of digestibility, total digestible nutrients and values per ton of these feeding stuffs were calculated. These calculations were supplemented with similar values obtained from the previous work (5) and an estimation made of the relative values of the two feeds. The following conclusions have been derived as to these comparative values.

(1) In the case of each feeding stuff, the coefficients of digestibility as calculated from a mixture of the feed with hay were lower than those obtained when the feeding stuff was fed alone.

(2) The digestibility of oat hulls was similar, in degree, to that of Vim Oat Feed. Certain differences were noted, however, with regard to the individual nutrients. The digestibility of the crude fibre of the oat hulls was markedly higher than that of the Vim Oat Feed, whereas the digestibility of the nitrogen-free extract was lower though not quite significantly. Further, it was not possible under the conditions of the experiments to determine a coefficient of digestibility for the nitrogen of oat hulls, whereas the coefficient for the nitrogen of the Vim Oat Feed was in the neighbourhood of 50.

(3) There was no significant difference between the total digestible nutrients per 100 lbs. in Vim Oat Feed and those in the oat hulls.

(4) Differences in the individual digestible nutrients per 100 lbs. corresponding to the differences in the coefficients of digestibility of the same nutrients were noted.

(5) When the digestible nutrients in the two feeds were expressed on a money basis, a significant difference in value was only noted when digestible protein was credited with a relatively high price. This difference, in favour of the Vim Oat Feed, was small but significant. It is due, in part, to the lack of a satisfactory coefficient of digestibility for the nitrogen of the oat hulls.

(6) Based upon these digestibility trials it is concluded that the feeding value of oat hulls is similar to that of Vim Oat Feed. Vim Oat Feed may be given a slightly higher rating because of the content of about 2 lbs. of digestible protein per 100 lbs., as compared with an undetermined smaller value for the oat hulls.

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## APPENDIX

TABLE 11.—COMPOSITION OF FEEDING STUFFS

| —— | Moisture | Ash | Protein (N × 6.25) | Ether extract | Crude fibre | N-free extract |
|---|---|---|---|---|---|---|
| *Vim Oat Feed* | | | | | | |
| Experiment AN 7–1 | 5.92 | 5 81 | 3.82 | 1.76 | 30.55 | 52.14 |
| Experiment AN 7–2 | 7.47 | 6 89 | 5.47 | 1.99 | 29.27 | 48.91 |
| *Hay* | | | | | | |
| Experiment AN 13–1 | 7.89 | 7.88 | 10.18 | 1 85 | 28.50 | 43.70 |
| Experiment AN 13–2 | 7.76 | 8.38 | 9.41 | 2.07 | 27.25 | 45.13 |
| Experiment AN 13–4 | 9.15 | 6.81 | 9.88 | 2.43 | 28.27 | 43.46 |
| Experiment AN 13–5 | 8.76 | 6.79 | 10.65 | 2.40 | 28.63 | 42.77 |
| *Oat Hulls* | | | | | | |
| Experiment AN 13–2 | 6.71 | 5.37 | 1.75 | 0.51 | 32.82 | 52.84 |
| Experiment AN 13–3 | 6.44 | 5.37 | 1.75 | 0.51 | 33.52 | 52.42 |
| Experiment AN 13–5 | 8.49 | 5.56 | 1.72 | 0.64 | 33.14 | 50.45 |

## TABLE 12.—CALCULATION OF COEFFICIENTS OF DIGESTIBILITY OF HAY IN EXPERIMENT AN 13-1

(Weights in kilogrammes. Collection period of 12 days)

| — | Dry matter | Organic matter | Nitrogen | Ether extract | Crude fibre | N-Free extract |
|---|---|---|---|---|---|---|
| *No. 84387J* | | | | | | |
| In feed | 82.899 | 75.807 | 1.465 | 1.665 | 25.650 | 39.330 |
| In feces | 33.359 | 28.034 | 0.594 | 1.168 | 11.027 | 12.257 |
| Digested | 49.540 | 47.773 | 0.871 | 0.497 | 14.623 | 27.073 |
| Coefficient | 59.8 | 63.0 | 59.0 | 29.9 | 57.0 | 68.8 |
| *No. 84381J* | | | | | | |
| In feed | 82.899 | 75.807 | 1.465 | 1.665 | 25.650 | 39.330 |
| In feces | 33.694 | 28.112 | 0.569 | 1.277 | 10.991 | 12.389 |
| Digested | 49.205 | 47.695 | 0.896 | 0.388 | 14.659 | 26.941 |
| Coefficient | 59.4 | 62.9 | 61.2 | 23.3 | 57.2 | 68.5 |
| *No. 84424J** | | | | | | |
| In feed | 75.990 | 69.490 | 1.343 | 1.526 | 23.513 | 36.053 |
| In feces | 30.707 | 25.618 | 0.554 | 1.078 | 10.290 | 11.011 |
| Digested | 45.283 | 43.872 | 0.789 | 0.448 | 13.223 | 25.042 |
| Coefficient | 59.6 | 63.1 | 58.8 | 29.4 | 56.2 | 69.5 |
| *No. 84422J* | | | | | | |
| In feed | 82.899 | 75.807 | 1.465 | 1.665 | 25.650 | 39.330 |
| In feces | 33.406 | 27.610 | 0.568 | 1.286 | 10.275 | 12.485 |
| Digested | 49.493 | 48.197 | 0.897 | 0.379 | 15.375 | 26.845 |
| Coefficient | 59.7 | 63.6 | 61.2 | 22.8 | 60.0 | 68.3 |

*Collection period of 11 days.

## TABLE 13.—CALCULATION OF COEFFICIENTS OF DIGESTIBILITY OF OAT HULLS IN EXPERIMENT AN 13-2

(Weights in kilogrammes. Collection period of 12 days)

| — | Dry matter | Organic matter | Nitrogen | Ether extract | Crude fibre | N-Free extract |
|---|---|---|---|---|---|---|
| *No. 84387J* | | | | | | |
| In feed | 88.865 | 81.723 | 1.077 | 1.519 | 27.831 | 45.638 |
| In feces | 42.344 | 36.612 | 0.489 | 1.003 | 12.918 | 19.788 |
| Digested | 46.521 | 45.111 | 0.588 | 0.516 | 14.913 | 25.850 |
| Coefficient | 52.4 | 55.2 | 54 6 | 34.0 | 53.6 | 56.6 |
| Digested from hay | 36.283 | 34.979 | 0.598 | 0.361 | 10.359 | 20.493 |
| Digested from hulls | 10.238 | 10.132 | — | 0.155 | 4.554 | 5.357 |
| Intake in hulls | 27.987 | 26.376 | 0.084 | 0.153 | 9.846 | 15.852 |
| Coefficient for hulls | 36.6 | 38.4 | — | — | 46.3 | 33.8 |
| *No. 84381J* | | | | | | |
| In feed | 88.865 | 81.723 | 1.077 | 1.519 | 27.831 | 45.638 |
| In feces | 45.198 | 39.431 | 0.498 | 0.934 | 14.677 | 20.802 |
| Digested | 43.667 | 42.292 | 0.579 | 0.585 | 13.154 | 24.836 |
| Coefficient | 49.2 | 51.8 | 53.8 | 38.5 | 47.3 | 54.4 |
| Digested from hay | 36.283 | 34.979 | 0.598 | 0.361 | 10.359 | 20.493 |
| Digested from hulls | 7.384 | 7.313 | — | 0.224 | 2.795 | 4.343 |
| Intake in hulls | 27.987 | 26.376 | 0.084 | 0.153 | 9.846 | 15.852 |
| Coefficient for hulls | 26.4 | 27.7 | — | — | 28.4 | 27.4 |

TABLE 13.—CALCULATION OF COEFFICIENTS OF DIGESTIBILITY OF OAT HULLS IN EXPERIMENT AN 13-2—*Concluded*

(Weights in kilogrammes. Collection period of 12 days)

| — | Dry matter | Organic matter | Nitrogen | Ether extract | Crude fibre | N-Free extract |
|---|---|---|---|---|---|---|
| *No. 84424J* | | | | | | |
| In feed | 116.852 | 108.099 | 1.161 | 1.672 | 37.677 | 61.490 |
| In feces | 65.760 | 57.622 | 0.591 | 1.080 | 20.977 | 31.959 |
| Digested | 51.092 | 50.477 | 0.570 | 0.592 | 16.700 | 29.531 |
| Coefficient | 43.7 | 46.7 | 49.1 | 35.4 | 44.3 | 48.0 |
| Digested from hay | 36.283 | 34.979 | 0.598 | 0.361 | 10.359 | 20.493 |
| Digested from hulls | 14.809 | 15.498 | — | 0.231 | 6.341 | 9.038 |
| Intake in hulls | 55.974 | 52.752 | 0.168 | 0.306 | 19.692 | 31.704 |
| Coefficient for hulls | 26.5 | 29.4 | — | 75.5 | 32.2 | 28.5 |
| *No. 84422J* | | | | | | |
| In feed | 116.852 | 108.099 | 1.161 | 1.672 | 37.677 | 61.490 |
| In feces | 65.160 | 57.506 | 0.564 | 1.166 | 20.688 | 32.073 |
| Digested | 51.692 | 50.593 | 0.597 | 0.506 | 16.989 | 29.417 |
| Coefficient | 44.2 | 46.8 | 51.4 | 30.3 | 45.1 | 47.8 |
| Digested from hay | 36.283 | 34.979 | 0.598 | 0.361 | 10.359 | 20.493 |
| Digested from hulls | 15.409 | 15.614 | — | 0.145 | 6.630 | 8.924 |
| Intake in hulls | 55.974 | 52.752 | 0.168 | 0.306 | 19.692 | 31.704 |
| Coefficient for hulls | 27.5 | 29.6 | — | 47.9 | 33.7 | 28.2 |

TABLE 14.—CALCULATION OF COEFFICIENTS OF DIGESTIBILITY OF OAT HULLS IN EXPERIMENT AN 13-3

(Weights in kilogrammes. Collection period of 12 days)

| — | Dry matter | Organic matter | Nitrogen | Ether extract | Crude fibre | N-Free extract |
|---|---|---|---|---|---|---|
| *No. 84387J* | | | | | | |
| In feed | 84.204 | 79.371 | 0.252 | 0.459 | 30.168 | 47.178 |
| In feces | 51.187 | 46.423 | 0.263 | 0.256 | 14.856 | 29.699 |
| Digested | 33.017 | 32.948 | — | 0.203 | 15.312 | 17.479 |
| Coefficient | 39.2 | 41.5 | — | 44.2 | 50.8 | 37.1 |
| *No. 84381J* | | | | | | |
| In feed | 84.204 | 79.371 | 0.252 | 0.459 | 30.168 | 47.178 |
| In feces | 51.597 | 47.244 | 0.240 | 0.222 | 15.484 | 30.152 |
| Digested | 32.607 | 32.127 | 0.012 | 0.237 | 14.684 | 17.026 |
| Coefficient | 38.7 | 40.5 | 4.8 | 51.6 | 48.7 | 36.1 |
| *No. 84424J* | | | | | | |
| In feed | 84.204 | 79.371 | 0.252 | 0.459 | 30.168 | 47.178 |
| In feces | 49.822 | 45.607 | 0.240 | 0.233 | 14.655 | 29.113 |
| Digested | 34.382 | 33.764 | 0.012 | 0.226 | 15.513 | 18.065 |
| Coefficient | 40.8 | 42.5 | 4.8 | 49.2 | 51.4 | 38.3 |
| *No. 84422J* | | | | | | |
| In feed | 84.204 | 79.371 | 0.252 | 0.459 | 30.168 | 47.178 |
| In feces | 48.565 | 44.103 | 0.227 | 0.271 | 14.511 | 27.920 |
| Digested | 35.639 | 35.268 | 0.025 | 0.188 | 15.657 | 19.258 |
| Coefficient | 42.3 | 44.4 | 9.9 | 41.0 | 51.9 | 40.8 |

TABLE 15.—CALCULATION OF COEFFICIENTS OF DIGESTIBILITY OF HAY IN EXPERIMENT AN 13–4

(Weights in kilogrammes. Collection period of 12 days)

| —— | Dry matter | Organic matter | Nitrogen | Ether extract | Crude fibre | N-Free extract |
|---|---|---|---|---|---|---|
| *No. 84387J* | | | | | | |
| In feed | 81.765 | 75.636 | 1.423 | 2.187 | 25.443 | 39.114 |
| In feces | 32.979 | 29.417 | 0.537 | 1.276 | 11.605 | 13.397 |
| Digested | 48.786 | 46.219 | 0.886 | 0.911 | 13.838 | 25.717 |
| Coefficient | 59.7 | 61.1 | 62.3 | 41.6 | 54.4 | 65.8 |
| *No. 84381J* | | | | | | |
| In feed | 81.765 | 75.636 | 1.423 | 2.187 | 25 443 | 39.114 |
| In feces | 33.476 | 29.811 | 0 521 | 1.274 | 11.984 | 13.458 |
| Digested | 48.289 | 45.825 | 0.902 | 0.913 | 13.459 | 25.656 |
| Coefficient | 59.1 | 60.5 | 63.4 | 41.8 | 52.9 | 65.6 |

TABLE 16.—CALCULATION OF COEFFICIENTS OF DIGESTIBILITY OF OAT HULLS IN EXPERIMENT AN 13–5

(Weights in kilogrammes. Collection period of 12 days)

| —— | Dry matter | Organic matter | Nitrogen | Ether extract | Crude fibre | N-Free extract |
|---|---|---|---|---|---|---|
| *No. 84387J* | | | | | | |
| In feed | 87.671 | 81 522 | 1.207 | 1 776 | 28.838 | 43.363 |
| In feces | 43 927 | 39 795 | 0 502 | 0 989 | 15.294 | 20.579 |
| Digested | 43 744 | 41 727 | 0.705 | 0 787 | 13.544 | 22.784 |
| Coefficient | 49.9 | 51 2 | 58.4 | 44.3 | 47.0 | 52.5 |
| Digested from hay | 35.770 | 33.888 | 0 708 | 0.661 | 10.147 | 18.546 |
| Digested from hulls | 7.974 | 7.839 | — | 0.126 | 3.397 | 4.238 |
| Intake in hulls | 27.453 | 25.785 | 0 082 | 0.192 | 9.942 | 15.135 |
| Coefficient for hulls | 29 1 | 30.4 | — | 65.6 | 34.2 | 28.0 |
| *No. 84381J* | | | | | | |
| In feed | 87.671 | 81 522 | 1.207 | 1.776 | 28.838 | 43.363 |
| In feces | 46 123 | 41.562 | 0.508 | 1 150 | 15.831 | 21.531 |
| Digested | 41 548 | 39.960 | 0.699 | 0 626 | 13.007 | 21.832 |
| Coefficient | 47.4 | 49 0 | 57 9 | 35 3 | 45.1 | 50.4 |
| Digested from hay | 35.770 | 33.888 | 0 708 | 0.661 | 10.147 | 18.546 |
| Digested from hulls | 5.778 | 6.072 | — | — | 2.860 | 3.286 |
| Intake in hulls | 27 453 | 25 785 | 0.082 | 0 192 | 9.942 | 15.135 |
| Coefficient for hulls | 21 1 | 23.6 | — | — | 28 6 | 21.7 |
| *No. 84424J* | | | | | | |
| In feed | 87.671 | 81.522 | 1.207 | 1.776 | 28.838 | 43.363 |
| In feces | 46.197 | 41.474 | 0.531 | 1.111 | 15.939 | 21.261 |
| Digested | 41.474 | 40.048 | 0 676 | 0.665 | 12.899 | 22.102 |
| Coefficient | 47.3 | 49.1 | 56.0 | 37.4 | 44.7 | 51.0 |
| Digested from hay | 35.770 | 33.888 | 0.708 | 0.661 | 10.147 | 18.546 |
| Digested from hulls | 5.704 | 6.160 | — | — | 2.752 | 3.556 |
| Intake in hulls | 27.453 | 25.785 | 0.082 | 0.192 | 9.942 | 15.135 |
| Coefficient for hulls | 20.8 | 23.9 | — | — | 27.7 | 23.5 |

TABLE 17.—CALCULATION OF COEFFICIENTS OF DIGESTIBILITY OF VIM OAT FEED IN EXPERIMENT AN 7–2

(Weights in kilogrammes. Collection period of 12 days)

| —— | Dry matter | Organic matter | Nitrogen | Ether extract | Crude fibre | N-Free extract |
|---|---|---|---|---|---|---|
| *No. 84424J* | | | | | | |
| In feed | 83.277 | 77.076 | 0.788 | 1.791 | 26.343 | 44.019 |
| In feces | 52.027 | 46.530 | 0.390 | 0.456 | 16.810 | 27.024 |
| Digested | 31.250 | 30.546 | 0.398 | 1.335 | 9.533 | 16.995 |
| Coefficient | 37.5 | 39.6 | 50.5 | 74.5 | 36.2 | 38.6 |
| *No. 84422J* | | | | | | |
| In feed | 83.277 | 77.076 | 0.788 | 1.791 | 26.343 | 44.019 |
| In feces | 50.918 | 45.463 | 0.366 | 0.513 | 16.712 | 26.074 |
| Digested | 32.359 | 31 613 | 0.422 | 1.278 | 9.631 | 17.945 |
| Coefficient | 38.9 | 41.0 | 53.6 | 71.4 | 36.6 | 40.8 |

## RÉSUMÉ

ÉTUDES DE L'AVOINE À BÉTAIL VIM (VIM OAT FEED). 2. DIGESTIBILITÉ DE LA BALLE D'AVOINE. C. J. Watson, G. W. Muir, et W. M. Davidson, Ferme expérimentale centrale, Ottawa.

Ces essais de digestibilité portaient sur des bœufs métis Shorthorn; l'aliment employé était de la balle d'avoine grossièrement moulue, avec et sans ration de foin, ainsi que de l'avoine à bétail Vim (*Vim Oat Feed*), finement broyée et donnée seule dans la ration. Les coefficients de digestibilité, la somme totale d'éléments nutritifs digestibles et la valeur par tonne de ces aliments ont été calculés d'après les résultats de ces essais. Ces calculs ont été complétés par des chiffres semblables obtenus dans des recherches précédentes, et une évaluation a été faite de la valeur relative des deux aliments. Voici les conclusions auxquelles on a abouti en ce qui concerne les valeurs comparatives.

Pour chaque aliment, les coefficients de digestibilité, lorsque l'aliment était donné avec du foin, étaient plus faibles que ceux que l'on obtenait lorsque l'aliment était donné seul. La digestibilité de la balle d'avoine était semblable jusqu'à un certain point à celle de la *Vim Oat Feed*, mais certaines différences ont été notées en ce qui concerne les principes nutritifs individuels. La cellulose brute de la balle d'avoine avait une digestibilité beaucoup plus forte que celle de la *Vim Oat Feed;* par contre, la digestibilité de l'extrait libre d'azote était moins élevée, mais la différence n'était pas grande. Il n'a pas été possible dans les conditions de ces expériences de déterminer un coefficient de digestibilité pour l'azote de la balle d'avoine, tandis que le coefficient pour l'azote de la *Vim Oat Feed* était d'à peu près 50. Il n'y avait pas de différence significative entre la *Vim Oat Feed* et la balle d'avoine en ce qui concerne le total d'éléments nutritifs digestibles par 100 livres. Des différences ont été notées dans les éléments nutritifs digestibles pris séparément, par 100 livres, correspondant aux différences dans les coefficients de digestibilité des mêmes éléments. Lorsque les éléments digestibles nutritifs des deux aliments étaient exprimés sur une base monétaire, on ne notait une différence significative de valeur que lorsque la protéine digestible était comptée à un prix relativement élevé. La différence en faveur de la *Vim Oat Feed* était faible mais significative. Elle provient en partie du fait que l'on n'a pas un coefficient satisfaisant de digestibilité pour l'azote de la balle d'avoine. En se basant sur ces essais de digestibilité, on peut conclure que la valeur alimentaire de la balle d'avoine est semblable à celle de la *Vim Oat Feed.* La *Vim Oat Feed* peut être classée un peu plus haut que la balle d'avoine parce qu'elle renferme environ 2 livres de protéine digestible par 100 livres, tandis que la quantité trouvée dans la balle d'avoine est un peu plus faible.

# RESISTANCE OF WILD OATS AND SOME COMMON CEREAL VARIETIES TO FREEZING TEMPERATURES[1]

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[Received for publication June 14, 1934]

## Introduction

The difficulties involved in the eradication of winter annual weeds are generally appreciated. Weeds with the annual habit, that commence growth in the fall after the usual tillage operations have been discontinued and survive the freezing temperatures of the winter months, present a serious problem to the grower who wishes to sow his crop early in the spring. The question has been raised often as to whether wild oats *(Avena fatua)* is a winter annual.

The wild oat problem became rather acute in the fall of 1933 in north central Alberta. The four-year period 1929-32 was relatively dry in this region, especially the late summer and fall of 1932. Soil moisture conditions were unfavourable for the rapid germination of wild oat seeds lying in the soil during this period. In the spring of 1933 conditions were very favourable for growth and the seeds which had been accumulating in the soil, as a result of unfavourable conditions for germination in preceding years, produced one of the heaviest infestations of wild oats that the north central part of the Province has experienced. Dockage on wheat for wild oats at the elevators frequently exceeded 25%.

Moisture was very plentiful in the fall of 1933, and favourable growing conditions were general until late November. Fields infested with wild oats produced a heavy crop of seedlings. With this situation many farmers who hold the belief that wild oats is a winter annual naturally became alarmed. Many others, who were uncertain regarding the growth habits of this weed, began to make inquiries regarding the possibility of wild oats surviving the winter. While the general opinion held by many farmers, and most technical workers, was that wild oats is not a winter annual, it seemed desirable to obtain more specific information regarding this character by conducting artificial freezing tests.

## Methods

In addition to wild oats, a cultivated variety of oats, Victory, was included in the test for comparison; also commonly-grown varieties of other cereals, namely: Marquis, Red Bobs No. 222, Reward and Garnet spring wheats; Trebi barley; Prolific spring rye; Kharkov No. 22 winter wheat; and Dakold winter rye. The plants were grown in the greenhouse in wooden flats, 16 × 26 inches and 4 inches deep. Twenty seeds of each variety were sown in single rows across each flat. The plants were frozen in a large refrigerator chamber specially constructed for studying the effect of freezing temperatures on plants.[3] The flats were replicated three times in three tests (Experiments A, B and C), and six times in one test (Experiment D).

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[1] Contribution from the Department of Field Crops, University of Alberta, Edmonton, Canada.
[2] Professor of Genetics and Plant Breeding and Field Assistant, respectively.
[3] The equipment for the refrigerating plant was furnished by the National Research Council of Canada.

The plants were hardened off and then exposed to low temperatures at the 3–4 leaf stage in Experiments A and B; and in the 5-leaf stage in Experiment D, according to a regular procedure developed in experiments on the testing of winter wheats for resistance to killing at low temperatures.[4] The hardening procedure consisted of successive exposures in the refrigerators for two nights (5.00 p.m.–8.00 a.m.) at 30° F. (−1° C.), two nights at 25° F. (−4° C.) and two nights at 20° F. (−7° C.). Each day the plants were returned to the greenhouse where favourable conditions for growth existed. In this process, even though there are 12° F. (7° C.) of frost on the fifth and sixth nights, there was practically no injury to the foliage of the plants. On the seventh night the plants were exposed for four hours to a temperature of 5° F. (−15° C.) in Experiments A and B, to 10° F. (−12° C.) in Experiment C; and to −10° F. (−23° C.) in Experiment D.

The plants were returned to the greenhouse the day after freezing and allowed a period of two weeks for recovery before the notes on injury were taken. A measure of the degree of injury to the plants was obtained by calculating a survival index. The degree of foliage injury to each individual plant was noted on a scale of 1 to 5; "1" represented complete killing, "5" no injury, and "2," "3" and "4" intermediate degrees of injury. This index of injury from low temperatures appeared to be a better measure of the ability of various varieties to resist injury to the foliage, than a mere percentage of plants surviving. Many of the plants that showed life two weeks after freezing, would probably never have recovered at all under the most favourable conditions in the field in the spring. For this reason simply recording the percentage survival may be misleading. That there is a high degree of relationship between the survival index and the survival percentage, however, is illustrated by the significant correlation coefficient between these two values of $+ 0.908 \pm 0.019$. Since both of these values may be of interest, however, they are given in Table I.

## EXPERIMENTAL RESULTS

Experiment "A" was conducted in December, when there was very little natural sunlight. Even though this was supplemented by artificial light, the plants were very spindly as compared with the usual stocky growth in the field. The results obtained with the ten cereal varieties under test are given in Table I. The data for each variety are given as average survival index, per cent of plants surviving, and rank according to degree of injury based on the survival index. It is quite evident that wild oats is the most susceptible to injury by low temperatures and also has the least ability to survive. It held the lowest rank under both methods of scoring. Two of the replicated flats in this experiment are shown in Figure 1.

Owing to the lack of normal growth of the plants used in Experiment "A," it seemed desirable to repeat the tests with stronger plants. This was done later in the winter when light conditions were more favourable for the production of strong, healthy plants. These tests were conducted on a more extensive scale and divided into three experiments. Experiment "B" was a repetition of Experiment "A," except for the difference in the

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[4] Unpublished results.

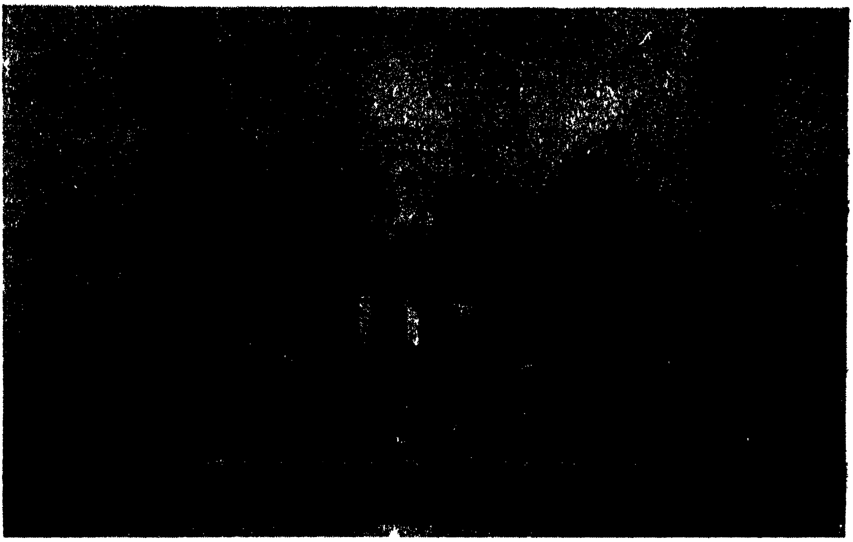

FIGURE 1 —Survival of Dakold (1) winter rye Kharkov No 22 (2) winter wheat Prolific (3) spring rye, Victory (4) oats Wild oats (5) Trebi (6) barley Marquis (7) Reward (8) Red Bobs No 222 (9) and Garnet (10) spring wheats when hardened and then frozen at 5° F (−15° C) for four hours Photographed two weeks after freezing

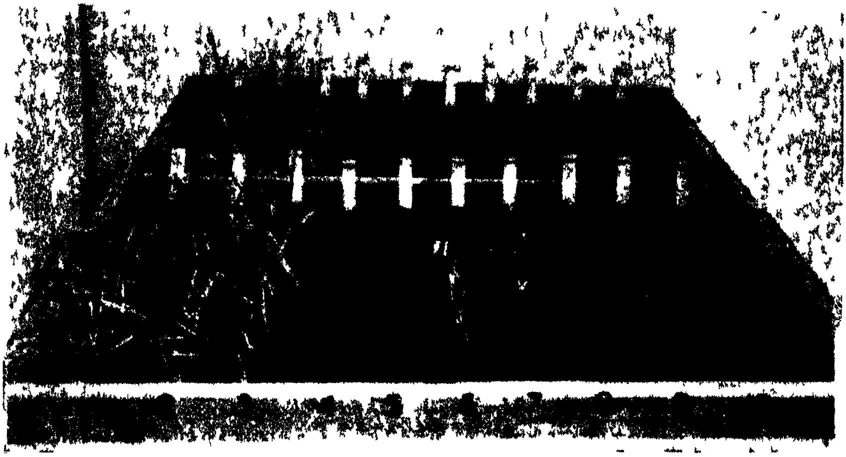

FIGURE 2 —Survival of Dakold (1) winter rye Kharkov No 22 (2) winter wheat Prolific (3) spring rye, Victory (4) oats Wild oats (5) Trebi (6) barley Marquis (7) Reward (8) Red Bobs No 222 (9) and Garnet (10) spring wheats when hardened and then frozen at −10° F (−23° C) for four hours All dead plants and leaves removed before photographing two weeks after freezing

growth of the plants. The data obtained are given in Table I. The results are very similar to those obtained in the first experiment, indicating that the inherent differences of the various cereals to resist injury by low temperatures are expressed approximately as well in this case by the spindly plants as by the stocky ones. Wild oats again showed the greatest injury, but a little higher survival percentage than did cultivated oats.

TABLE 1.—SURVIVAL AND RELATIVE HARDINESS OF WILD OATS AND SOME CEREAL VARIETIES WHEN EXPOSED TO VARIOUS FREEZING TEMPERATURES IN THE SEEDLING STAGE

| Variety | *C.A.N. | Experiment A. 5° F. (−15° C.) Survival | | | Experiment B. 5° F. (−15° C.) Survival | | | Experiment C. 10° F. (−12° C.) Survival | | | Experiment D. −10° F. (−23°C.) Survival | | | Average Survival | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Index | Per cent | Rank | Index | Per cent | Rank | Index | Per cent | Rank | Index | Per cent | Rank | Index | Per cent | Rank |
| Dakold—winter rye | — | 88.2 | 100.0 | 1 | 84.5 | 100.0 | 1 | 79.3 | 100.0 | 3 | 70.5 | 95.9 | 1 | 80.6 | 99.0 | 1 |
| Kharkov No. 22—winter wheat | 2360 | 85.8 | 100.0 | 2 | 71.3 | 88.5 | 3 | 68.5 | 100.0 | 4 | 70.1 | 94.7 | 2 | 73.9 | 95.8 | 2 |
| Prolific—spring rye | — | 36.6 | 79.3 | 5 | 71.9 | 90.8 | 2 | 88.4 | 95.6 | 1 | 31.2 | 58.0 | 3 | 57.0 | 80.9 | 3 |
| Trebi—barley | 753 | 39.4 | 92.1 | 4 | 64.1 | 95.7 | 4 | 87.2 | 100.0 | 2 | 11.8 | 28.1 | 4 | 50.6 | 79.0 | 4 |
| Red Bobs No. 222 spring wheat | 1637 | 51.7 | 89.6 | 3 | 59.4 | 82.3 | 5 | 68.5 | 96.2 | 5 | 1.2 | 4.6 | 6 | 45.2 | 68.2 | 5 |
| Marquis spring wheat | 1621 | 29.2 | 60.4 | 7 | 49.7 | 68.8 | 6 | 63.1 | 80.8 | 7 | 2.7 | 10.8 | 5 | 36.2 | 55.2 | 6 |
| Reward spring wheat | 1509 | 32.9 | 70.3 | 6 | 39.2 | 58.8 | 7 | 64.2 | 77.7 | 6 | 0.0 | 0.0 | 7 | 34.1 | 51.7 | 7 |
| Garnet spring wheat | 1316 | 18.2 | 52.9 | 9 | 22.4 | 45.3 | 8 | 46.9 | 80.4 | 8 | 0.0 | 0.0 | 7 | 21.9 | 44.7 | 8 |
| Victory—oats | 284 | 25.4 | 73.2 | 8 | 15.3 | 20.4 | 9 | 42.3 | 71.1 | 9 | 0.0 | 0.0 | 7 | 20.8 | 41.2 | 9 |
| Wild oats | — | 8.6 | 27.4 | 10 | 13.8 | 25.1 | 10 | 16.7 | 27.5 | 10 | 0.0 | 0.0 | 7 | 9.8 | 20.0 | 10 |

*C.A.N.—Canadian Accession Number.

In certain years no natural hardening takes place in the field before the temperature drops sufficiently low to do considerable injury to volunteer plants, or crops of fall sown cereals. Experiment "C" was planned to test the susceptibility of the various cereals to low temperatures without previous hardening off. In this test the plants were placed in the refrigerator for two nights at 33° F. (1° C.) and then frozen for four hours at a temperature of 10° F. (−12° C.). The data obtained from this test are given as "Experiment C" in Table I.

The results obtained are in agreement with those obtained in the first two experiments, except that the two winter cereals, Kharkov No. 22 and Dakold, showed considerable foliage injury, in contrast to the hardier spring cereals, when not hardened previous to freezing. This is in agreement with the results obtained in the studies on hardiness in winter wheat and illustrates the need for a hardening-off process previous to exposure to the low or differential temperatures. In this experiment wild oats showed a considerably greater weakness in both foliage injury and non-survival. The difference between wild oats and Victory oats is especially interesting. The former has a survival index of 16.7 and a percentage survival of 27.5, while the latter had a survival index of 42.3 and a percentage survival of 71.1.

Since none of the temperatures used in the above experiments were completely lethal for any of the cereals, a fourth experiment was conducted to determine the relative susceptibility to killing at a temperature which was lethal to one or more of the varieties in the test. In the studies on winter hardiness referred to above, it was found that an exposure at −10° F. (−23° C.) for eight hours produced differential killing on segregating hybrid populations between spring and winter wheats. An exposure at this same temperature for twelve hours, produced differential killing on various winter wheat varieties; and at sixteen hours on wheat-rye hybrids and winter rye varieties.

In Experiment "D" the plants were hardened in the usual way, and then on the seventh night exposed to a temperature of −10° F. (−23° C.) for four hours. The data obtained are given as "Experiment D" in Table I.

Wild oats, Victory oats, Garnet and Reward wheats were completely killed in this test. Marquis and Red Bobs No. 222 were almost completely defoliated, but 10.8% and 4.6% respectively of the plants survived. These differences between the spring wheats are, in general, in agreement with previous extensive studies made on the resistance of spring wheat varieties to seedling injury by frost (1). The resistance of Marquis to frost injury has been noted in the Pacific Coast region, where it is sometimes grown as a fall wheat.

The foliage of Trebi barley and Prolific spring rye was severely injured, but 28.1% and 58.0%, respectively, of the plants survived. These results are in agreement with general field observations made by the senior writer, where it has been noted that both of these cereals are in general more resistant to spring and summer frosts than oats and spring wheat. The two winter cereals, as expected, showed some foliage injury but very little killing. The results obtained in this experiment are illustrated in Figure 2.

## FIELD OBSERVATIONS

Stands of wild oats were located in several fields in the fall of 1933. Fields showing a wide variety of conditions were selected for observation of not only wild oats, but also of the commonly grown spring cereals. In no instance, when growth had commenced in the fall, was there any indication of wild oats or cultivated varieties of spring wheat, oats or barley surviving the winter.

## DISCUSSION AND SUMMARY

The above experimental results and observations corroborate the view that there is little possibility, if any, of wild oats surviving the winter in central and northern Alberta when growth starts in the previous year. This fact lends support to the recommendation that stubble land should be disked in the fall in order to make conditions more favourable for the germination of wild oat seeds lying on the surface of the soil, and so promote their destruction by winter killing.

## REFERENCE

1. NEWTON. R. Hearing on Garnet wheat. Proceedings of Select Standing Committee on Agriculture and Colonization, Canadian House of Commons, p. 104. April, 1932.

## RÉSUMÉ

**RÉSISTANCE DE LA FOLLE AVOINE ET DE CERTAINES VARIÉTÉS ORDINAIRES DE CÉRÉALES AUX TEMPÉRATURES DE CONGÉLATION.** O. S. Aamodt et A. W. Platt, Université de l'Alberta, Edmonton, Alberta.

Des expériences conduites dans des conditions contrôlées et s'appuyant sur des observations faites dans le champ, confirment l'idée que la folle-avoine n'a que peu ou point de chances de résister à l'hiver dans le centre et le nord de l'Alberta lorsqu'elle a commencé à pousser l'année précédente. Ce fait démontre l'utilité du système de lutte recommandé, qui consiste à disquer le chaume en automne pour créer des conditions soient plus favorables à la germination de la graine de la folle-avoine reposant à la surface du sol, provoquant ainsi sa destruction par l'hiver.

# IMPROVEMENT OF RYE THROUGH INBREEDING[1]

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[Received for publication March 20, 1934]

## INTRODUCTION

Selection in self-fertilized lines is apparently the most logical method of improving naturally cross-pollinated crops. Among these crops, maize has been studied extensively in this respect, while rye has been much less investigated. The methods found suitable for maize can in general be applied to rye. Rye breeding, however, presents some special problems. Ordinary cultivated rye has been shown by many investigators to be partially self-sterile, the character being heritable, while maize is, as a rule, practically completely self-fertile. Rye grown under ordinary field conditions, where cross-pollination is not artificially interfered with, shows considerable unfruitfulness. Usually about one-third of the florets fail to set seed. In maize the seed setting is much higher. The lower seed setting in rye is probably due in part to the same heritable factors that bring about partial self-sterility and if this is the case it should be possible to improve the productivity of rye by using self-fertilized lines of high self-fertility as breeding stock. The purpose of the present paper is to report a study of the inbreeding method applied to rye with special reference to increasing seed setting and seed weight.

## LITERATURE REVIEW

Since Rimpau (*17*), in 1877, demonstrated the partial self-sterility of cultivated rye, *Secale cereale* L., various studies have been made on the effect of self-pollination in this crop. It will be possible here to give only a brief review of those findings that have a direct bearing on the present study. It has been found (*e.g.*, *1*, *5*, *6*, *7*, *14*, *16*, *20*, *21*) that when individual plants of ordinary cultivated rye are isolated by space, or when the heads of single plants are covered with parchment bags or other agents suitable for enforcing self-pollination, the majority of the plants set little or no seed. A small proportion of the self-pollinated plants are usually highly self-fertile. The average seed setting in the first year of self-pollination has been, in most cases, well below 10%. Not only do plants within a variety differ in degree of self-fertility but varieties differ also. It has been found that self-fertility in rye is heritable and that it is possible to increase the degree of self-fertility of a variety by selection.

Continued inbreeding of rye without selection has been shown to result always in reduced vigour of the progeny on the average as compared with open pollinated material. Selection may bring out inbred strains showing no degeneration (*5*, *6*, *14*, *15*). Abnormalities such as chlorophyll deficiency and dwarfing often appear in inbred material.

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[1] Abridgment of a thesis submitted to the Faculty of the Graduate School, University of Minnesota, in partial fulfilment of the requirements for the degree of Doctor of Philosophy, December, 1933. Contribution from the Division of Agronomy and Plant Genetics, Minnesota Agricultural Experiment Station, St. Paul, Minn. Paper No. 1261 of the Journal Series, Minnesota Agricultural Experiment Station.

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Fruwirth (*13*) crossed two pure lines of rye and found that, when the $F_1$ was allowed to cross-pollinate, the yield excelled that of the parents.

Von Rumker and Leidner (*18*) showed that cross-fertilized plants gave a higher yield than the pure line parents.

Bredemann and Heuser (*4*) studied the effect of heterosis in rye by making crosses between varieties differing for yield. In the majority of cases the $F_1$ and $F_2$ excelled both parents in yield of grain and straw. The yield decreased in general in $F_3$ and $F_4$. In $F_4$ the yield was intermediate between those of the parents. Mechanical mixtures of equal parts of two varieties were tested in comparison with the parents, many combinations of varieties being made. In general the yield was approximately the same as the average of the parents. The hybrid generation from such mixtures showed an increased yield.

Schribaux (*19*) grew a mixture of equal parts of local and Petkus rye in comparison with the former. The mixture and several generations of its progeny gave a higher yield than the local rye.

Leith (*16*) found that over a three-year period approximately one third of the florets of rye grown in the field failed to set seed. There was much variation.

In most of the work reported on inbreeding of rye, parchment bags were used as an isolating agent. Space isolation appears to allow of a more accurate measure of fertility but is impractical if many plants are to be tested. Cloth wrappings of various kinds have proved unreliable. Berg (*3*) has used the method of sealing the glumes with gum arabic.

## EXPERIMENTAL MATERIAL

The studies here reported were confined almost entirely to Minnesota No. 2 rye which originated as a mass selection from Swedish rye. The materials used were inbred strains of Minnesota No. 2 developed at University Farm, St. Paul, by Dr. H. K. Hayes and Dr. H. E. Brewbaker. Dr. Hayes began isolating the strains in 1916, using space isolation, and started self-fertilization work in 1920. Dr. Brewbaker continued the study with the same material in the fall of 1921. Glassine bags were used for several years, although, from 1925 until the present report, parchment bags were used, and, as a rule, several spikes of each selfed plant were enclosed in a bag. Brewbaker (*5*) found that most of the self-pollinated plants were highly self-sterile, but that a small proportion of them showed relatively high self-fertility. Strains were maintained year after year by successive selfing. Selections were made each year from plants showing high self-fertility and good seed, and several strains apparently breeding true for high self-fertility were isolated. Several strains of low self-fertility were produced also by selecting in successive years for that character. In 1926 the results up to that time were published (*5*). In 1929 Dr. Brewbaker made crosses between self-pollinated strains representing low and high levels of seed setting to study the effect of various combinations, and in 1930 he selfed the $F_1$ plants. In 1931 the material was made available to the writer for studies in fertility and seed setting. Table 1 gives the history of the strains used in the crosses. In the column headed "Parent plant" is given the percentage seed setting of the plants used to obtain progeny the following year. Three of the 9 strains were first selfed in 1921,

TABLE 1.—PERCENTAGE SEED SETTING IN SELFED STRAINS OF MINNESOTA NO. 2 RYE. HISTORY OF STRAINS USED IN CROSSES FOR FERTILITY STUDIES

| Number plants selfed | Average | Range | Parent plant | Number plants selfed | Average | Range | Parent plant | 1929 culture number |
|---|---|---|---|---|---|---|---|---|
| 1923 % Seed setting | | | | 1924 % Seed setting | | | | |
| 9 | 1.0 | 0.0 - 3.0 | 51.7* | 12 | 9.2 | 0.0 - 25.4 | 25.4 | 348 |
| 6 | 4.7 | 0.0 - 25.7 | 2.1 | 4 | 29.7 | 1.5 - 76.1 | 76.1 | 355 |
| 11 | 5.0 | 0.0 - 19.5 | 7.5 | 11 | 19.5 | 0.0 - 76.8 | 76.8 | 366 |
| 16 | 7.6 | 0.0 - 53.1 | 53.1 | 17 | 12.6 | 0.0 - 66.2 | 37.5 | 325 |
| 15 | 1.5 | 0.0 - 6.0 | 57.3* | 8 | 12.6 | 0.0 - 81.3 | 81.3 | 338 |
| 10 | 2.7 | 0.0 - 16.4 | 16.4 | 13 | 9.2 | 0.8 - 43.4 | 43.4 | 377 |
| 12 | 2.5 | 0.0 - 12.5 | 12.2 | 6 | 10.2 | 0.0 - 34.0 | 34.0 | 389 |
| 1925 % Seed setting | | | | 1926 % Seed setting | | | | |
| 4 | 20.3 | 2.0 - 62.9 | 62.9 | 4 | 55.7 | 27.3 - 85.9 | 66.3 | 348 |
| 4 | 51.5 | 41.2 - 60.0 | 60.0 | 3 | 29.8 | 20.5 - 35.0 | 35.0 | 355 |
| 5 | 31.4 | 0.0 - 69.0 | 69.0 | 8 | 24.7 | 0.0 - 47.4 | 47.4 | 366 |
| 4 | 2.6 | 0.0 - 6.0 | 6.0 | 9 | 8.2 | 0.0 - 58.9 | 10.2 | 321 |
| 4 | 3.2 | 0.5 - 7.7 | 3.6 | 9 | 4.3 | 0.0 - 21.1 | 21.1 | 325 |
| 3 | 1.2 | 0.0 - 2.9 | 1.9 | 5 | 7.2 | 1.3 - 28.8 | 28.8 | 338 |
| | | | | | | | 1.3 | |
| 4 | 1.3 | 0.8 - 1.6 | 1.4 | 5 | 9.9 | 0.0 - 56.7 | 1.8 | 377 |
| 5 | 9.2 | 0.0 - 16.7 | 16.7 | 12 | 1.7 | 0.0 - 5.4 | 5.4 | 389 |
| 1927 % Seed setting | | | | 1928 % Seed setting | | | | |
| 5 | 84.7 | 67.5 - 98.9 | 67.5 | 1 | 70.5 | — | 70.5 | 348 |
| 8 | 23.4 | 0.0 - 60.0 | 53.5 | 7 | 60.6 | 33.3 - 95 9 | 95.9 | 355 |
| 2 | 59.9 | 36.9 - 72.9 | 72.9 | 3 | 57.4 | 52.1 - 67.5 | 52.1 | 366 |
| 2 | 59.9 | 36.9 - 72.9 | 72.9 | 3 | 57.4 | 52.1 - 67.5 | 52.5 | 367 |
| 6 | 3.5 | 0.0 - 7.3 | 1.6 | — | — | — | — | 321 |
| 11 | 3.7 | 0.3 - 9.0 | 9.0 | — | — | — | — | 325 |
| 5 | 3.9 | 0.6 - 12.5 | 12.5 | 9 | 1.2 | 0.0 - 6.8 | 3.7 | 338 |
| 3 | 5.0 | 0.0 - 14.7 | 14.7 | — | — | — | — | 377 |
| 4 | 2.2 | 1.0 - 3.7 | 3.7 | — | — | — | — | 389 |
| 1929 % Seed setting | | | | No. years selfed before 1929 | | | | |
| 17 | 51.5 | 32.1 - 97.8 | | 1 + 5‡ | High self-fertility | | | 348 |
| 8 | 63.2 | 42.7 - 78.3 | | 7 | High self-fertility | | | 355 |
| 4 | 32.2 | 23.1 - 46.2 | | 8 | High self-fertility | | | 366 |
| 7 | 39.6 | 9.3 - 68.1 | | 8 | High self-fertility | | | 367 |
| 2 | 42.9 | 3.6 - 82.2 | | 3 | Low self-fertility | | | 321 |
| 9 | 13.4 | 0.9 - 72.6† | | 5 | Low self-fertility | | | 325 |
| 5 | 0.5 | 0.0 - 2.5 | | 1 + 5 | Low self-fertility | | | 338 |
| 9 | 0.9 | 0.0 - 3.3 | | 7 | Low self-fertility | | | 377 |
| 3 | 7.5 | 2.5 - 13.3 | | 2 + 5 | Low self-fertility | | | 389 |

*This plant was sibbed. †The range was 0 9–8.8 with the exception of one plant which was 72.6. ‡The plus sign indicates 1 year sibbed; *e.g.*, 1 + 5 indicates 1 year selfed followed by 1 year sibbed and this followed by 5 years selfed.

4 in 1922, 1 in 1923 and 1 in 1925. All strains came from different original selections in Minnesota No. 2 rye, except cultures 366 and 367. Both of these came from the same 1928 culture but in no case were they both used in the same cross in 1929. Hence all crosses were between strains that had been kept separate since the original selections were made from

Minnesota No. 2 rye. One strain (No. 410) which was used in one of the crosses was a highly self-fertile selection from the variety Abruzzes obtained from Dr. E. B. Mains of Purdue University. It had been selfed 8 years.

## EXPERIMENTAL METHODS

In self-pollinating rye plants the method used by Brewbaker (5) was followed. Several heads of a plant were enclosed in a parchment bag shortly before anthesis and the bag was tied to a stake for support. The heads were left thus enclosed until ripe. This method makes possible the isolation of a large number of plants in a small space but it has some disadvantages. Less seed is set than under conditions of space isolation. Moreover, when a large amount of material is handled, it is impossible to make certain that no off-pollination takes place. The later plants are bagged when there is a great deal of pollen in the air. Some pollen grains may become lodged in the glumes of heads before they are covered and bring about fertilization later when the stigma becomes receptive. The occasional occurrence of apparently self-fertile plants in highly self-sterile strains might be explained on this basis.

In determining the percentage of florets setting seed, only the lateral florets were considered. Only occasionally was a seed found in the third floret of a spikelet.

## EXPERIMENTAL RESULTS

### INCREASING SELF-FERTILITY

A general idea of the rate of increase of self-fertility when strains of rye are selfed in successive years and selection is practised may be obtained from the strains selfed in 1932. These ranged from strains that had been selfed for the third time up to others that were selfed for the twelfth time. Table 2 summarizes the data.

TABLE 2.—PERCENTAGE SEED SETTING FOR SELFED STRAINS IN 1932

| No. of generations selfed | No. of strains* | Average per cent of lateral florets setting seed |
|---|---|---|
| 3 | 28 | 4.8 |
| 5 | 7 | 19.7 |
| 6 | 58 | 29.1 |
| 7 | 12 | 43.1 |
| 8 | 3 | 46.6 |
| 11 | 4 | 30.6 |
| 12 | 11 | 41.8 |

*The average number of plants selfed per strain was 4.5.

The material consisted of strains derived from those represented in Table 1 as well as strains from Dr. Hayes' breeding plots developed in the same way and which he kindly made available for this summary. Strains developed by sibbing as well as selfing are not included in Table 2.

It will be seen from this table, as well as Tables 1, 3 and 4 that in strains that have been selected for high self-fertility for several years the average percentage seed setting is usually between 20 and 60. In strains that have been selected for several years for low self-fertility the average percentage seed setting is usually below 10. Although the former group is far from being completely self-fertile, it is of definitely higher self-fertility than the latter group. Hence, for convenience and simplicity the terms high self-fertility and low self-fertility are used in this paper in referring to groups of this kind. It will be noted that there is great variability of seed setting in the high self-fertility group. Part of this variability may be due to environmental factors alone, for covering the heads of self-fertile varieties of small grains causes a variation in seed setting in some cases.

## $F_1$ RESULTS—1930

Plants of several of the high and low fertility strains and the $F_1$ progeny of the 1929 crosses were selfed. These crosses may be grouped as follows

TABLE 3.—FREQUENCY DISTRIBUTION OF SELF-POLLINATED PLANTS FOR PERCENTAGE SEED SETTING IN 1930. SELFED LINES AND $F_1$ PROGENY OF 1929 CROSSES

| 1929 origin (Plant No.) | 0 | 0.1 to 9.9 | 10.0 to 19.9 | 20 0 to 29 9 | 30.0 to 39.9 | 40.0 to 49.9 | 50.0 to 59.9 | 60.0 to 69.9 | 70.0 to 79.9 | 80.0 to 89.9 | 90.0 to 99.9 | Total plants | Average percentage seed setting † |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| High fertility lines | | | | | | | | | | | | | |
| 366–4 | | | | | | 1 | 3 | | | | | 4 | 52.8 |
| 348–5 | | | | | 1 | | | | | | | 1 | 31.1 |
| 348–6 | | | | | | | | 1 | | 1 | | 2 | 72.7 |
| 348–7 | | | | 3 | 3 | 1 | 3 | 2 | | | | 12 | 42.5 |
| 348–14 | | | | 1 | | 1 | | 1 | | | | 3 | 47.1 |
| 348–22 | 1 | | | | 4 | | 1 | 1 | | | | 7 | 36.2 |
| 348–23 | 1 | | | | 1 | | | | | | | 2 | 16.4 |
| 355–5 | 2 | 3 | 1 | | | | 1 | | | | | 7 | 12.1 |
| Low fertility lines | | | | | | | | | | | | | |
| 321–2 | 5 | | | | | | | | | | | 5 | 0.0 |
| 325–9 | 1 | 1 | | | | | | | | | | 2 | 0.2 |
| 325–10 | 1 | | | | | | | | | | | 1 | 0.0 |
| 325–3 | | 2 | | 1 | | | | | | | | 3 | 7.7 |
| 325–4 | 1 | 1 | | | | | | | | | | 2 | 4.5 |
| 325–7 | 1 | | | | | | | | | | | 1 | 0.0 |
| 377–9 | 2 | | 1 | | | | | | | | | 3 | 6.0 |
| 389–3 | 2 | 2 | | | | | | | | | | 4 | 0.4 |
| 389–5 | 1 | 2 | | | | | | | | | | 3 | 0.8 |
| High × High $F_1$ | | | | | | | | | | | | | |
| 355–5 × 348–1 | 1 | | | | | | 1 | 4 | 1 | | | 7 | 56.2 |
| 366 × 348 | | 1 | | | 1 | 1 | | 3 | 1 | 5 | | 12 | 63.3 |
| 348–6 × 410–3* | 1 | | 1 | | | 2 | | | | 2 | | 6 | 46.1 |
| High × Low $F_1$ (including Low × High) | | | | | | | | | | | | | |
| 377–9 × 348–11 | 4 | 1 | 3 | 2 | 4 | 4 | 3 | 3 | 3 | 1 | | 28 | 39.4 |
| 377–5 × 355–5 | 2 | | 1 | 1 | | 3 | | 1 | | | | 8 | 29.8 |
| 367–7 × 389–1 | | | | | | | | | | 3 | 4 | 7 | 91 9 |
| 338–1 × 367–1 | 1 | | | | | | | | 5 | 6 | 3 | 15 | 79.1 |
| 366–8 × 321–2 | 3 | | 1 | | | 1 | | 2 | 3 | 2 | | 12 | 47.8 |
| 366–5 × 321–2 | | | | | | | | | 1 | | | 1 | 74.1 |
| 366–5 × 325–10 | 4 | 3 | | | | | 2 | 1 | 2 | 1 | 1 | 14 | 37.9 |
| 325–9 × 348–14 | 3 | 1 | | | 1 | | | 5 | 8 | 1 | | 19 | 56.8 |
| 325–10 × 348–1 | | | | | | | 4 | 2 | | | | 6 | 57.9 |
| Low × Low $F_1$ | | | | | | | | | | | | | |
| 338–5 × 321–2 | 9 | 12 | 2 | 2 | | | | | | | | 25 | 5.2 |
| 325–9 × 321–2 | 8 | 11 | | | | | | | | | | 19 | 1.5 |

* Minnesota No. 2 × Abruzzes.

† The averages given in this and the following tables are calculated from actual values and not from the groupings used in the tables.

with reference to the degree of self-fertility of the parents:

High × High[1]
Low × Low
High × Low
Low × High.

The average percentage seed setting of crossed plants in 1929 was as follows:—

| | | |
|---|---|---|
| High × High | 34.7 | (26 crosses) |
| High × Low | 30.8 | (12 crosses) |
| Low × High | 42.8 | (15 crosses) |
| Low × Low | 74.3 | (2 crosses, 78.6 and 70.0). |

The differences are probably largely due to differences in technique as several assistants were employed, but the data clearly show that the Low × Low crosses were fertile. Table 3 gives the percentage seed setting of selfed plants in the various groups in 1932. The variability within the high fertility lines and $F_1$ progenies would seem to be due chiefly to environmental factors. With variability as great as this, one could not hope to establish definite ratios in the segregating $F_2$ progenies. The High × High $F_1$ plants are similar to the high fertility parents for seed setting and the Low × Low plants are similar to the low fertility parents. This is interesting in view of the fact that the Low × Low cross was quite fertile. The somewhat higher seed setting in the High × High $F_1$ group as compared with the parents may be due to hybrid vigour. The High × Low $F_1$ plants resemble the high fertility rather than the low fertility plants for seed setting. There would appear to be two possible interpretations of these data. If the partial sterility is a true gametic sterility then high fertility is apparently dominant. The sterility may, however, be due to differential pollen tube growth as in *Nicotiana* and several other genera (*8*). The fact that the Low × Low cross was fertile but that the selfed $F_1$ progeny of this cross was highly sterile favours the latter hypothesis. This will be dealt with in the discussion at the end of the paper.

### $F_2$ RESULTS—1931

In 1931 the following material was grown and selfed:—

Strains of high self-fertility,
Strains of low self-fertility,
$F_2$ progeny of 1929 crosses.

The $F_2$ progeny were grown from seed of selfed $F_1$ plants. The seed setting of the high and low fertility lines (see Table 4) was, in general, similar to that of the previous year except that the former had somewhat lower seed setting in 1931 than in 1930. The single plant of high fertility in the low fertility class may be due to a single floret being accidentally open-pollinated the previous year. No clear-cut Mendelian ratios can be derived from the $F_2$ progenies. Again there is an apparent dominance of high over low self-fertility. Heribert-Nilsson (*14*), however, obtained some evidence based on a small number of plants that self-sterility in rye is dominant over self-fertility. The same interpretations as given in the previous section would apply here.

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[1] In naming the crosses, "High" and "Low" will mean "high self-fertility" and "low self-fertility" respectively.

TABLE 4.—FREQUENCY DISTRIBUTION OF SELF-POLLINATED PLANTS FOR PERCENTAGE SEED SETTING IN 1931. SELFED LINES AND $F_2$ PROGENY OF 1929 CROSSES

| No. of 1931 cultures | 1929 origin ( Plant No.) | 0 | 0.1 to 9.9 | 10.0 to 19.9 | 20.0 to 29.9 | 30.0 to 39.9 | 40.0 to 49.9 | 50.0 to 59.9 | 60.0 to 69.9 | 70.0 to 79.9 | 80.0 to 89.9 | 90.0 to 99.9 | Total plants | Average percentage seed setting |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | High fertility lines | | | | | | | | | | | | | |
| 4 | 366–4 | 9 | 34 | 17 | 10 | 2 | | | | | | | 72 | 9.9 |
| 3 | 348–6 | 2 | 3 | 8 | 8 | 10 | 6 | 1 | | | | | 38 | 27.6 |
| 9 | 348–7 | 1 | 1 | 2 | 3 | 2 | 4 | 4 | 3 | 1 | | | 21 | 40.9 |
| 4 | 348–14 | | | 4 | 2 | 6 | 3 | | 3 | | | | 18 | 35.6 |
| 6 | 348–22 | 1 | 9 | 3 | | | 1 | | 4 | 2 | 1 | | 21 | 28.4 |
| 1 | 348–23 | | | 1 | | | | | | | | | 1 | 15.3 |
| 2 | 355–5 | | 1 | 1 | | | | | | | | | 2 | 6.8 |
| | Low fertility lines | | | | | | | | | | | | | |
| 3 | 325–3 | 15 | 18 | | | | | | | | | | 33 | 1.3 |
| 1 | 325–4 | 1 | 3 | | | | | 1 | | | | | 5 | 12.0 |
| | High × High $F_2$ | | | | | | | | | | | | | |
| 4 | 355–2 × 348–1 | 1 | 2 | 2 | 1 | 1 | 3 | | 2 | | | | 12 | 30.0 |
| 6 | 355–5 × 348–1 | 2 | 2 | 9 | 29 | 65 | 76 | 70 | 28 | 10 | 1 | 1 | 293 | 44.7 |
| 8 | 366–4 × 348–7 | 1 | 2 | 4 | 13 | 20 | 42 | 71 | 64 | 45 | 5 | 1 | 268 | 55.6 |
| 1 | 348–6 × 410–3* | | 2 | | 3 | 3 | 7 | 5 | 5 | 3 | | | 28 | 46.8 |
| | High × Low $F_2$ | | | | | | | | | | | | | |
| 18 | 377–9 × 348–11 | 4 | 20 | 35 | 51 | 91 | 90 | 90 | 34 | 9 | 3 | | 427 | 40.2 |
| 1 | 377–5 × 355–5 | 1 | 6 | 8 | 9 | 19 | 6 | 5 | 3 | 1 | | | 58 | 32.1 |
| 7 | 367–7 × 389–9 | 2 | 15 | 26 | 35 | 37 | 45 | 35 | 21 | 6 | 1 | 2 | 225 | 38.5 |
| 6 | 338–1 × 367–1 | 4 | 8 | 20 | 21 | 38 | 29 | 53 | 34 | 18 | 3 | 2 | 230 | 45.3 |
| | Low × Low $F_2$ | | | | | | | | | | | | | |
| 13 | 338–5 × 321–2 | 23 | 34 | 3 | | 5 | 1 | | 1 | 1 | | | 68 | 7.7 |
| 9 | 325–9 × 321–2 | 17 | 6 | | 1 | | | | | 1 | | | 25 | 5.0 |

*Minnesota No. 2 × Abruzzes.

In the Low × Low $F_2$ group there are several rather highly self-fertile plants suggesting recessive factors for high self-fertility. It is possible that there are both dominant and recessive factors for this condition. In view of the small number of self-fertile plants in this group, however, it is not improbable that they are due to cross pollination in $F_1$ as explained under Experimental Methods.

Table 5 summarizes the $F_1$ and $F_2$ data. In order to give a general picture of the distribution of the progeny of crosses with respect to self-fertility, results of crosses of the same kind have been combined, even though the same factors may not be involved in each of the crosses. Figure 1 gives a graphical representation of the distributions given in Table 5.

The kernels of selfed low fertility lines were on the average smaller and lighter in weight than those produced by high fertility lines. The kernels of the Low × Low $F_2$ plants were also much smaller on the average than those of High × High $F_2$ and High × Low $F_2$. There was a difference in viability as well. When seeds were potted in the greenhouse, approximately 70% of those from Low × Low $F_2$ plants and 90% of those from High × High $F_2$ plants produced seedlings.

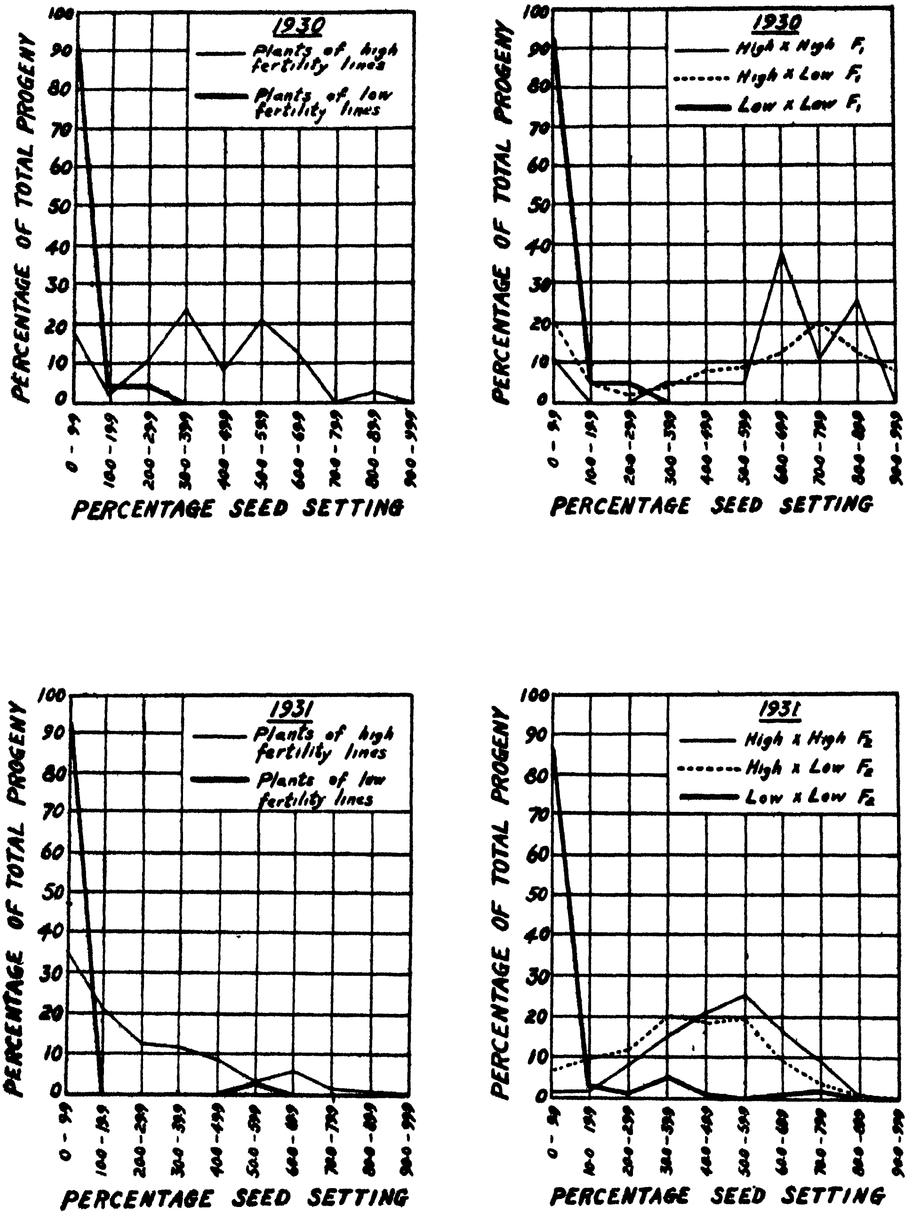

FIGURE 1. Distribution of selfed plants for percentage seed setting in strains of high and of low self-fertility and in progenies of crosses. Data from Table 5.

TABLE 5.—SUMMARIZED FREQUENCY DISTRIBUTION OF SELF-POLLINATED PLANTS FOR PERCENTAGE SEED SETTING FROM TABLES 2, 3 AND 4

| Group | 0 | 0.1 to 9.9 | 10.0 to 19.9 | 20.0 to 29.9 | 30.0 to 39.9 | 40.0 to 49.9 | 50.0 to 59.9 | 60.0 to 69.9 | 70.0 to 79.9 | 80.0 to 89.9 | 90.0 to 99.9 | Total plants | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1930 | | | | | | | | | | | | | |
| High fertility lines | 4 | 3 | 1 | 4 | 9 | 3 | 8 | 5 | | 1 | | 38 | 37.1 |
| Low fertility lines | 14 | 8 | 1 | 1 | | | | | | | | 24 | 2.3 |
| High × High $F_1$ | 1 | 1 | | | 1 | 1 | 1 | 7 | 2 | 5 | | 19 | 60.7 |
| High × High $F_1$ | 1 | | 1 | | | 2 | | | | 2 | | 6 | 46.1 |
| High × Low $F_1$ | 17 | 5 | 5 | 3 | 5 | 8 | 9 | 14 | 22 | 14 | 8 | 110 | 52.5 |
| Low × Low $F_1$ | 17 | 23 | 2 | 2 | | | | | | | | 44 | 3.6 |
| 1931 | | | | | | | | | | | | | |
| High fertility lines | 13 | 48 | 36 | 23 | 20 | 14 | 5 | 10 | 3 | 1 | | 173 | 22.5 |
| Low fertility lines | 16 | 21 | | | | | 1 | | | | | 38 | 2.7 |
| High × High $F_2$ | 4 | 6 | 15 | 43 | 86 | 121 | 141 | 94 | 55 | 6 | 2 | 573 | 49.5 |
| High × High $F_2$* | | 2 | | 3 | 3 | 7 | 5 | 5 | 3 | | | 28 | 46.8 |
| High × Low $F_2$ | 11 | 49 | 89 | 116 | 185 | 170 | 183 | 92 | 34 | 7 | 4 | 940 | 40.5 |
| Low × Low $F_2$ | 40 | 40 | 3 | 1 | 5 | 1 | | 1 | 2 | | | 93 | 7.0 |

*Minnesota No. 2 × Abruzzes.

## $F_3$ RESULTS—1932

In 1932 $F_3$ material was grown and selfed as follows:-

| Cross | Number of lines | Average number of plants selfed per line |
|---|---|---|
| High × High (348–6 × 410–3) | 25 | 16.4 |
| High × Low (377–9 × 348–11) | 25 | 16.6 |
| Low × Low (338–5 × 321–2) | 24 | 4.7 |

The seed used was from selfed $F_2$ plants. Each of the three groups descended from a single selfed $F_1$ plant. The small number of plants available for selfing in the Low × Low $F_3$ group was due to the low seed-setting of $F_2$ plants and to the dying of many weak plants in $F_3$. In each of 12 $F_3$ lines in the Low × Low group only one plant survived to maturity. Such a plant would be the strongest and probably the most highly self-fertile plant in a line. This would tend to raise the level of self-fertility in $F_3$ as compared to $F_2$.

The percentage seed setting of $F_3$ plants was determined and the mean for each line calculated. Figure 2 shows the distribution of these means. It appears that in the particular High × Low cross tested here low self-fertility cannot be inherited as a simple Mendelian character since in 25 strains there would almost certainly be some averaging below 30% for seed setting. A more complex inheritance would account for the absence of such strains. So also would selection of pollen through differential rate of pollen tube growth. The Low × Low curve shows a preponderance of low fertility strains and here again as in $F_2$ there are some strains with moderately high fertility. Since almost one half of the $F_2$ plants of the Low × Low crosses set no seed and therefore had no progeny, there has been a marked selection for self-fertility. This accounts for

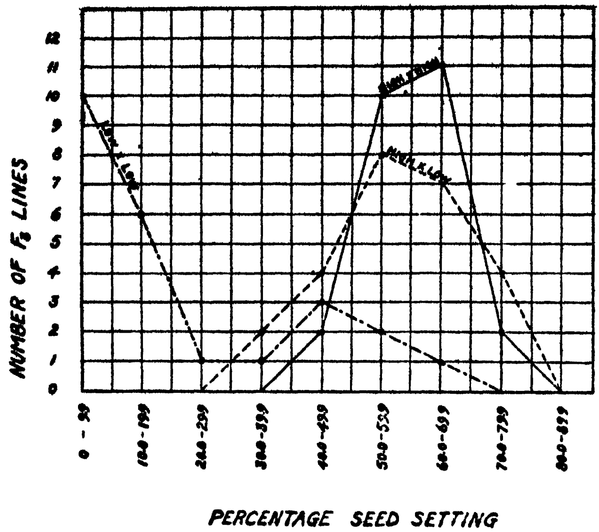

FIGURE 2. Distribution of $F_3$ lines for average percentage seed setting of selfed plants

the average seed setting being higher in $F_3$ than in $F_2$. The Low × Low results for $F_1$, $F_2$ and $F_3$ would indicate that hybrid vigour alone is not sufficient to bring about high self-fertility.

From the results of the crosses it would be expected that in rye grown under ordinary field conditions the presence of factors for low self-fertility might have some effect in lessening the seed setting since the apparent dominance of high self-fertility does not seem to be quite complete.

Correlation coefficients for the average per cent seed setting of $F_3$ lines in 1932 and the percentage seed setting of the $F_2$ parent plants in 1931 were calculated. These are as follows:—

| Cross | r | t | p |
|---|---|---|---|
| High × High | +.511 | 2 851 | Less than .01 |
| High × Low | +.255 | 1.265 | |
| Low × Low | −.016 | | |

In the High × High cross, it is plain that the correlation coefficient for $F_2$ and $F_3$ seed setting is significant. In the High × Low cross the correlation coefficient is not significant, while in the Low × Low cross it is close to zero. It might have been expected that the most significant correlation coefficient would have been obtained from the High × Low group since the parents were here more strongly contrasted with respect to self-fertility than in the other groups. The parents in the High × High cross, however, were developed from two distinct varieties and probably differed in a large number of factors affecting self-fertility more or less. In the other crosses, the parents all came from Minnesota No. 2 rye and probably had many factors in common. This may account in part for the high correlation coefficient in the High × High cross as compared with the other groups. Since in one half of the $F_3$ lines of the Low × Low cross only one plant was obtained for study, one would not expect the data to be accurate enough to give a significant correlation coefficient based on a sample of only 24 lines.

It is evident that the characters of high and low self-fertility are heritable. Yet it appears that the correlation of seed setting for different years is not as a rule very high. Brewbaker (*5*) reports "a correlation of the percentage seed setting in 1925 of 45 strains which had been selfed 3, 4, or 5 years with the percentage seed setting of the same strains for 1924 gives a correlation coefficient of 0.2044 ± 0.0963." The same writer studied data of Heribert-Nilsson (*14*) by computing a correlation coefficient for percentage seed setting of 42 strains in two consecutive years. The calculated coefficient was 0.1709 ± 0.1010. The measure of significance here used is the probable error. It is evident that these coefficients can not be regarded as significant.

## THE EFFECT OF COMBINING SELECTED SELF-FERTILIZED LINES—1933

The work in 1933 consisted of a comparative study of Minnesota No. 2 rye and three "synthetic" varieties produced by combining selected self-fertilized lines of Minnesota No. 2. This was undertaken to determine whether any improvement had been attained, particularly in seed setting and kernel weight, and to determine the effect of genes for sterility or low fertility on seed setting in a population of rye grown under ordinary field conditions where open pollination takes place.

In 1931 Dr. Hayes selected 36 rye plants to be combined to produce three new rye varieties. The plants were the result of continued selfing in Minnesota No. 2 rye with selection for self-fertility, plump seed, and good general appearance in the field. The selfed seed was bulked in three groups as shown in Table 6, the three being characterized by colourless, light-green, and dark-green seed respectively. The bulked seed was sown in three space-isolated plots in the fall of 1931 for increase. This material was made available to the writer for seed setting studies.

TABLE 6.—THE ORIGIN OF THREE NEW VARIETIES PRODUCED FROM MINNESOTA NO. 2 RYE

| No. of 1931 plants | Average No. of years selfed | Average % seed setting of the selected plants | Disposal |
|---|---|---|---|
| 11 | 6 | 68 8 | Bulked for a colourless selection to be called Minnesota No. 111 |
| 8 | 6 | 63 8 | Bulked for a light-green selection to be called Minnesota No. 112 |
| 17 | 5 | 74 5 | Bulked for a green selection to be called Minnesota No. 113 |

All the seed taken from the three plots in 1932 was from natural pollination. In 1933 a replicated test was planned. In each of three districts in Manitoba, Canada, viz. Winnipeg, Teulon and Rosser, the three synthetic varieties and the original Minnesota No. 2 rye were grown. The plots were 20 ft. × 20 ft. in size. In each district the four varieties were grown on the same field except in the case of Winnipeg where it was necessary to put variety No. 112 in a field apart from the rest. The culture of the two fields, however, had been similar. The plots were in every case at least 600 feet apart. The locations for the plots having been chosen, the varieties were assigned to them at random. The four varieties were grown at University Farm, St. Paul, primarily for increase. These plots were not of uniform size, but approximately so, and the data from them were included in the study, making four replicates in all. One plot (No. 112) was entirely destroyed at Teulon by ice smothering. The stands in the remaining plots were satisfactory.

The percentage seed setting was obtained on a random sample of 100 heads from each of the 15 plots. Two spikelets were removed from the top and two from the bottom of each spike and the counts were made on the lateral florets of the remaining spikelets. The means for the percentage seed setting of the hundred heads in each sample are given in Table 7. The standard errors of the means given here were obtained from calculating the standard deviation of each 100-head sample separately.

TABLE 7.—MEANS AND STANDARD ERRORS FOR PERCENTAGE SEED SETTING OF 100 HEADS OF RYE IN EACH OF FOUR VARIETIES AT EACH OF FOUR LOCALITIES

| —— | Minn. No. 2 | Minn. No. 113 | Minn. No. 112 | Minn. No. 111 |
|---|---|---|---|---|
| Winnipeg | 72.55<br>± 1.68 | 77.76<br>± 1.42 | 81.20<br>± 1.30 | 83.31<br>± 1.43 |
| Teulon | 71.25<br>± 1.62 | 75.34<br>± 1.51 | (78.56)* | 84.33<br>± 1.15 |
| Rosser | 69.48<br>± 1.66 | 75.40<br>± 1.64 | 75.41<br>± 1.64 | 77.48<br>± 1.41 |
| St. Paul | 75.76<br>± 1.54 | 73.19<br>± 1.36 | 77.02<br>± 1.74 | 81.72<br>± 1.34 |
| Variety means | 72.76 | 75.42 | 78.05 | 81.71 |

*Estimated by Allan and Wishart's method (2).

The new varieties showed a higher seed setting than Minnesota No. 2 in all districts with one exception: Minnesota No. 113 had a lower seed setting than Minnesota No. 2 at St. Paul. The value for the missing plot at Teulon was estimated by the method of Allan and Wishart (*2*). This made it possible to use all the available data in an analysis of variance. This analysis is given in Table 8, and is of the form developed by Fisher (*12*). In this analysis "districts" corresponds to "blocks" in the ordinary

TABLE 8.—SEED SETTING ANALYSIS OF VARIANCE COMPARING THREE SYNTHETIC VARIETIES WITH MINNESOTA NO. 2 RYE

| —— | Sums of squares | Degrees of freedom | Variance or mean square | ½ log$_e$ | z | 5% point | 1% point |
|---|---|---|---|---|---|---|---|
| Varieties | 192.6362 | 3 | 64.2121 | 2.0811 | 1.2889 | 0.7014 | 1.0135 |
| Districts | 38.0494 | 3 | 12.6831 | 1.2701 | 0.4779 | 0.7014 | 1.0135 |
| Error | 39.0190 | 8 | 4.8774 | 0.7922 | | | |
| Total | 269.7046 | 14 | | | | | |

randomized block test. There are only 8 degrees of freedom for error instead of 9, one being lost due to fitting the value for the missing plot. The approximate value of $z$ for a comparsion of variance due to varieties and that due to error is 1.2889. The value of $z$ at the 1% point for $n_1 = 3$ and $n_2 = 8$, given in Fisher's table (*17*) is 1.0135. So we may conclude that there were quite significant differences between varieties for seed setting. The standard error of a variety mean in this test is $\sqrt{4.8774/4}$ or 1.1042. For the mean of variety No. 112, however, for which one plot was missing, the standard error is $\sqrt{4.8774/3}$ or 1.2751. The standard error of a difference between two variety means is $\sqrt{2} \times 1.1042$ or 1.5616. When variety No. 112 is one of the two varieties being compared, the standard error of the difference would be $\sqrt{4.8774/4 + 4.8774/3}$ or 1.6868. If a difference between two variety means is 3.355 times as great as the standard error of the difference, the probability of the difference being due to chance is .01. If the difference is 2.896 times as great as the standard error the corresponding probability is .02. Hence the following varietal differences appear to be significant:—

Minn. No. 111 — Minn. No. 2 = 8.95 d/S.E. = 5.73
Minn. No. 112 — Minn. No. 2 = 5.29 d/S.E. = 3.14
Minn. No. 111 — Minn. No. 113 = 6.29 d/S.E. = 4.03

This shows that not only were there significant differences between Minnesota No. 2 rye and the synthetic varieties but also between the synthetic varieties themselves. The differences in seed setting due to districts cannot be judged to be significant in this test.

The weight per 1,000 kernels, height, and average number of spikelets per spike for the fifteen plots were determined. The first character was studied to determine the effect of selection for plump seed. The other two characters were studied in an attempt to determine whether the varieties differed in vigour. The height averages were based on ten measurements in each plot. The average number of spikelets per spike was determined from the same 100 heads per plot used to determine the per cent of seed setting. In each case the value for the missing plot was estimated by means of the method of Allan and Wishart. The mean values for all districts were as follows:—

| —— | Minn. No. 2 | Minn. No. 113 | Minn. No. 112 | Minn. No. 111 |
|---|---|---|---|---|
| 1000-kernel weight (grams) | 21.9 | 23.2 | 24.6 | 23.0 |
| Height (inches) | 45.2 | 44.8 | 49.0 | 49.0 |
| No. of spikelets per spike | 28.6 | 29.0 | 28.5 | 28.3 |

It is interesting that all of the synthetic varieties had a higher mean kernel weight than Minnesota No. 2. An analysis of variance showed that differences due to varieties and those due to districts were both significant. The kernel weight of variety 112 was significantly greater than that of Minnesota No. 2.

The data for height and for number of spikelets per spike were analyzed in the same way. In both cases the variance due to districts was highly significant while that due to varieties was not.

Comparative yield tests of the new varieties have not yet been made There can be little doubt, however, that a variety excelling Minnesota No. 2 in both kernel-weight and seed setting will also excel in yield. Whether the synthetic varieties will maintain their superiority over Minnesota No. 2 rye in later generations still remains to be determined.

## DISCUSSION

It has already been shown by various studies that factors for different degrees of self-fertility and self-sterility can be isolated in rye by means of self-pollination. From the results of the crosses here reported it appears that, in some cases at any rate, strains of very low self-fertility may be highly fertile when crossed with other strains of low self-fertility but that the progeny of the cross will be of low self-fertility like the parental strains. In a population made up of a mixture of strains of low self-fertility with open pollination taking place year after year the obligatory cross-fertilization would insure a fairly high degree of heterozygosis, an advantage from the standpoint of survival. But if the wind pollination is not mechanically perfect some florets will not be fertilized. When different strains of high self-fertility are crossed not only is the cross fertile but the progeny are self-fertile. In populations of highly self-fertile plants the degree of heterozygosis would tend to be less than in the previous case due to self-pollination. However, many florets that received no foreign pollen would yet set seed through self-pollination, an obvious advantage. Strains of high self-fertility, crossed with others of low self-fertility give results very similar to those of the High ×High crosses, but the self-fertility of the progeny is somewhat lower.

The improved seed setting of the synthetic strains as compared with Minnesota No. 2 rye is no doubt due in part to high self-fertility making possible the self-fertilization of florets which received no foreign pollen and would otherwise have set no seed. If hybrid vigour plays an important part in the degree of seed setting, part of the improvement may be lost in later generations of this material, as self-pollination lowers the degree of heterozygosis.

In actual practice full advantage could be taken of both hybrid vigour and selection of genes for self-fertility, seed size, etc., if the farmer grew as a commercial crop a hybrid population from seed produced by growing a mixture of a few carefully selected pure lines. These lines should be alike for such obvious characters as seed colour and should be selected for high fertility and large kernels. It would be necessary to grow each year small isolated plots of the pure lines and also one plot of a mixture of the lines of sufficient size to produce seed for the commercial crop the following year. A few pure lines selected from a single variety would be satisfactory material as shown in this study.

The work reported here was carried on from the standpoint of a plant breeding program and the detailed genetic studies necessary for determining the basis of sterility in rye were not carried out. The data obtained, however, give some indications of the nature of sterility in rye. In the study of the basis of sterility in plants, two main hypotheses have been useful, that of selective pollen tube growth and that of gametic sterility. The former, advanced by East and Mangelsdorf (*10*) with supporting evidence from genetic studies in *Nicotiana* is summarized briefly by East (*8*) as follows:—

"There is an allelomorphic series of genes of such a nature that pollen tubes having a given sterility gene grow slowly in style tissue having the same sterility gene in its constitution and rapidly in style tissue having a different sterility gene in its constitution. The ordinary result of these varying rates of pollen tube growth is that a plant of constitution $S_1S_2$ cannot be fertilized by its own pollen or by pollen from any other source bearing either of these sterility factors; but can be fertilized by pollen bearing a different sterility factor, such as $S_3$."

Thus such crosses as $S_1S_1 \times S_2S_2$, $S_1S_2 \times S_1S_3$ or $S_1S_2 \times S_3S_4$, where both parents are self-sterile but differ by at least one S factor, would be fertile but the $F_1$ plants would be self-sterile like the parents.

The results of the rye studies here reported agree, as far as they go, with this hypothesis. The sterility in rye, however, is not so complete as in *Nicotiana*. In this paper the terms high and low self-fertility have been used. The strains of very low self-fertility might be said to have a high degree of self-sterility. The two crosses between plants of low self-fertility, viz., 338–5 × 321–2 and 325–9 × 321–2, were fertile, but the selfed $F_1$ plants were similar to the parents in having low self-fertility. These results could be explained by the presence of allelomorphic factors similar to those of the S series in *Nicotiana*. It is apparent that on this basis culture 321 must differ from both 338 and 325 by at least one sterility factor.

If the allelomorphic S factors were the only factors differentiating the degree of sterility in the Low × Low crosses, the $F_2$ and $F_3$ selfed plants would be expected to be highly as self-sterile as the $F_1$. But since a few fertile plants appeared in $F_2$ and still more in $F_3$ it would appear that subsidiary factors affecting fertility may have been present. Selfing would bring about a rigid selection in favour of such factors. These fertile plants, however, possibly arose through cross-pollination in $F_1$.

East and Yarnell (*11*) reported the finding of a fertility factor $S_f$ belonging to the S series of allelomorphs in *Nicotiana*. It has been shown since by East and his co-workers that this factor evokes rapid pollen-tube growth in all combinations. When plants homozygous for known self-sterility factors were crossed with plants homozygous for the $S_f$ factor (*9*) the $F_1$ plants $S_fS_n$ were self-fertile. These were sterile to $S_n$ pollen but fertile to $S_f$ pollen and consequently the selfed $F_1$ plants yielded $F_2$ populations consisting of equal numbers of plants belonging to the two classes $S_fS_f$ and $S_fS_n$, both being self-fertile. The fact that the $F_1$, $F_2$ and $F_3$ plants from the High × High and High × Low crosses of rye here reported were as highly self-fertile as the parents of high self-fertility points to an explanation of self-fertility in rye similar to that proven for *Nicotiana*.

Although the High × High and High × Low crosses gave very similar results, the $F_1$, $F_2$ and $F_3$ progenies of the latter seem to be somewhat lower in self-fertility than those of the former. There are several plausible explanations. $S_fS_n$ (High × Low $F_1$) plants may not be as fully self-fertile as $S_fS_f$ (High × High $F_1$) plants, at any rate only one half of the pollen of the former group would behave normally in self-pollination. Also since the self-sterility dealt with here is not complete, a few seeds not bearing the $S_f$ factor might be formed on $S_fS_n$ plants through fertilization by $S_n$ pollen. These would give rise to plants of low self-fertility in later generations. It is possible that the low self-fertility of the one parent was due in part to subsidiary factors for gametic incompatibility. The effect of these would appear in $F_1$, $F_2$ and $F_3$.

## SUMMARY

A study was made of the use of self-fertilized lines in rye breeding with special reference to the increase of seed setting and seed size. With the exception of one strain from the variety Abruzzes, the material used originated from a bulk selection of Swedish rye known as Minnesota No. 2.

Self-pollination in the same year of various strains that had been selfed for different numbers of generations with selection for self-fertility showed that there was a progressive increase in self-fertility for several generations and that from the seventh generation onward the average percentage seed setting of the strains remained in general fairly uniform.

Strains selfed for a number of years and showing different degrees of self-fertility were crossed. $F_1$, $F_2$, and $F_3$ progeny were selfed. The progeny of crosses between highly self-fertile strains showed a higher average per cent seed setting in $F_1$, $F_2$, and $F_3$ than the parents. Similar results were obtained when strains of high self-fertility were crossed with strains of low self-fertility, but in general the seed setting was slightly lower and there was more variability.

In crosses between strains of low self-fertility the progeny were for the most part like the parents. A small proportion of the plants in $F_2$ were rather highly self-fertile. This proportion increased somewhat in $F_3$ due to the survival of the self-fertile plants and the loss of many self-sterile and weak plants in $F_2$.

There is an apparent dominance of high self-fertility over low self-fertility crosses, but the results might be better explained on the basis of selective pollen tube growth.

Seed from the selfed $F_2$ plants of High × High and High × Low self-fertility strains was plumper and had greater germinating ability than seed from the $F_2$ of Low × Low self-fertility strains.

Self-fertilized lines of Minnesota No. 2 rye having high self-fertility were combined to make three "synthetic" varieties. The three "hybrid" populations from these mixtures were compared with Minnesota No. 2 rye in four replicates each in a different district. All three synthetic varieties had a higher average seed setting and 1,000-kernel weight than Minnesota No. 2 rye. Using Fisher's analysis of variance, it was shown that two of the synthetic varieties had a significantly higher percentage seed setting than Minnesota No. 2 rye and the third synthetic variety. One of the new varieties had a significantly higher kernel weight than Minnesota No. 2.

No significant differences between varieties for height or for number of spikelets per spike were established.

It will be necessary to test later generations of this material to determine how much of the improvement will be permanent in successive generations with open pollination.

## ACKNOWLEDGMENT

The writer is indebted to Dr. H. K. Hayes of the University of Minnesota for the material on which the studies here reported were made. Grateful acknowledgment is also made to Dr. Hayes for his helpful advice and criticism throughout the studies and in the preparation of the manuscript.

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# RÉSUMÉ

**L'AMÉLIORATION DU SEIGLE PAR LA REPRODUCTION EN CONSANGUINITÉ.** R. F. Peterson, Laboratoire fédéral de recherches sur la rouille, Winnipeg, Man.

Cette étude portait sur l'emploi d'espèces auto-fécondées dans la multiplication du seigle. Elle se rapportait principalement à la formation de la graine et à la grosseur de la graine. A l'exception des espèces de la variété des Abruzzes, tous les matériaux employés provenaient d'une sélection en masse de seigle suédois appelée Minnesota No. 2. L'auto-pollinisation effectuée pendant la même année, de différentes espèces qui avaient été pollinisées pendant différent nombre de générations en vue d'accroître l'auto-fécondité, a fait voir qu'une augmentation progressive d'auto-fécondité se produit pendant plusieurs générations et qu'à partir de la septième génération le pourcentage moyen de semences formées sur les différentes espèces reste en général assez uniforme. On a croisé entre elles des espèces qui avaient été auto-fécondées pendant un certain nombre d'années et qui présentaient différents degrés d'auto-fécondité. La progéniture de $F_1$, $F_2$ et $F_3$ a été auto-fécondée. La progéniture des croisements entre les espèces hautement auto-fertiles a révélé une proportion moyenne plus forte de formation de semences dans $F_1$, $F_2$ et $F_3$ que dans les parents. On a obtenu les mêmes résultats lorsque des espèces de forte auto-fertilité étaient croisées avec des espèces de faible auto-fertilité, mais en général la quantité de semences formée était un peu plus faible et il y avait plus de variations. Dans les croisements entre les espèces à faible auto-fertilité, la plupart des sujets de la progéniture étaient comme leurs parents. Une petite proportion des plants dans $F_2$ étaient plutôt hautement auto-fertiles. Cette proportion a quelque peu augmenté dans $F_3$ à cause de la survivance des plants auto-fertiles et de la perte de nombreux plants faibles et auto-stériles dans $F_2$. Les croisements à forte auto-fertilité paraissent dominer sur ceux à faible auto-fertilité, mais les résultats s'expliquent peut-être mieux sur la base de la végétation sélective du tube du pollen. La semence provenant des plantes auto-fécondées $F_2$ des espèces Forte x Forte et Forte x Faible auto-fécondées, était mieux nourrie et avait une faculté germinative plus forte que la semence issue des espèces $F_2$ à auto-fécondation Faible x Faible. On a combiné les lignes auto-fécondées du seigle Minnesota No. 2 ayant une haute auto-fertilité, pour obtenir trois variétés synthétiques. Les trois populations hybrides issues de ces mélanges ont été comparées avec le seigle Minnesota No. 2 en quatre replicatas, chacun dans un district différent. Toutes ces trois variétés synthétiques avaient une plus haute moyenne de formation de semence et un poids plus élevé par 1,000 grains que le seigle Minnesota No. 2. Si l'on emploie l'analyse des variations de Fisher, on voit que deux des variétés synthétiques avaient un pourcentage de formation de semences beaucoup plus élevé que le seigle Minnesota No. 2 et la troisième variété synthétique. Une des nouvelles variétés avait un poids par boisseau beaucoup plus élevé que le Minnesota No. 2. Il n'a pas été établi de différences significatives entre les variétés pour la hauteur ou le nombre d'épillets par épi. Il sera nécessaire d'étudier les dernières générations de ces matériaux pour voir quelle proportion de cette amélioration sera permanente dans les générations successives, à pollinisation libre.

# AN ACCOUNT OF THE EASTERN HEMLOCK LOOPER, *ELLOPIA FISCELLARIA* Gn., ON BALSAM FIR

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[Received for publication February 15, 1934]

## INTRODUCTION

The hemlock looper is a comparative newcomer to the ranks of pulpwood pests in Eastern Canada, though it has been known for some years to be destructive to balsam in Newfoundland. As the popular name suggests, the insect is partial to the hemlock (*Tsuga canadensis*), and numerous outbreaks of the insect have occurred in hemlock forests in Ontario and in the Lake States; in some of these outbreaks, notably in Wisconsin and Michigan, the balsam as well as other coniferous and deciduous trees have been affected, though hemlock seems to be preferred to all other food-plants wherever it is available.

The hemlock looper is native to North America. It is widely distributed, the range extending from the Atlantic to the mid-western states; in Canada it is known to occur from Manitoba eastwards.

## OUTBREAKS IN QUEBEC AND NOVA SCOTIA

Previous to 1928, the insect was unknown as a pulpwood pest in Canada; since that date, however, several outbreaks on balsam fir have been known to occur, all in the province of Quebec. In the year 1928, on the North Shore of the Gulf of St. Lawrence, outbreaks appeared in a number of localities from Pentecost to Bersimis, involving about one million cords of balsam. In the same year a small, localized outbreak occurred on the Wesseneau river, in the St. Maurice valley. In 1930, the Dominion Forest Service reported a flight of moths in the vicinity of Mitchinamekus Lake, on the headwaters of the Lièvre river and an unconfirmed report indicated that caterpillars were numerous near Chibougamau, north of the Transcontinental Railway. Moths were also reported to be abundant and widely distributed in the counties of Richmond and Guysborough in Nova Scotia.

The outbreak on the North Shore was the only one which could be considered to have reached decidedly serious proportions; this region supports some of the finest stands of pulpwood in the province of Quebec and previous to 1928 had been apparently immune from serious insect outbreaks. The district had not been affected by the spruce budworm, which in 1910 and succeeding years ravaged the Saguenay and South Shore districts and which later swept through New Brunswick. The North Shore outbreak, developing as it did in highly valuable stands of balsam, was naturally viewed with anxiety, since a considerable amount of timber had been killed in one year and there was every indication that the outbreak would continue in virulence for several years to come.

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## BIONOMICS

Biological studies on the hemlock looper were initiated on the North Shore in 1929 and continued in 1930; while the study of the infestation was commenced primarily with a view to determining the bionomics of the insect, the course of investigations covered also the possibilities of artificial control by means of aerial dusting and properly conducted logging operations.

### GENERAL APPEARANCE OF AN OUTBREAK

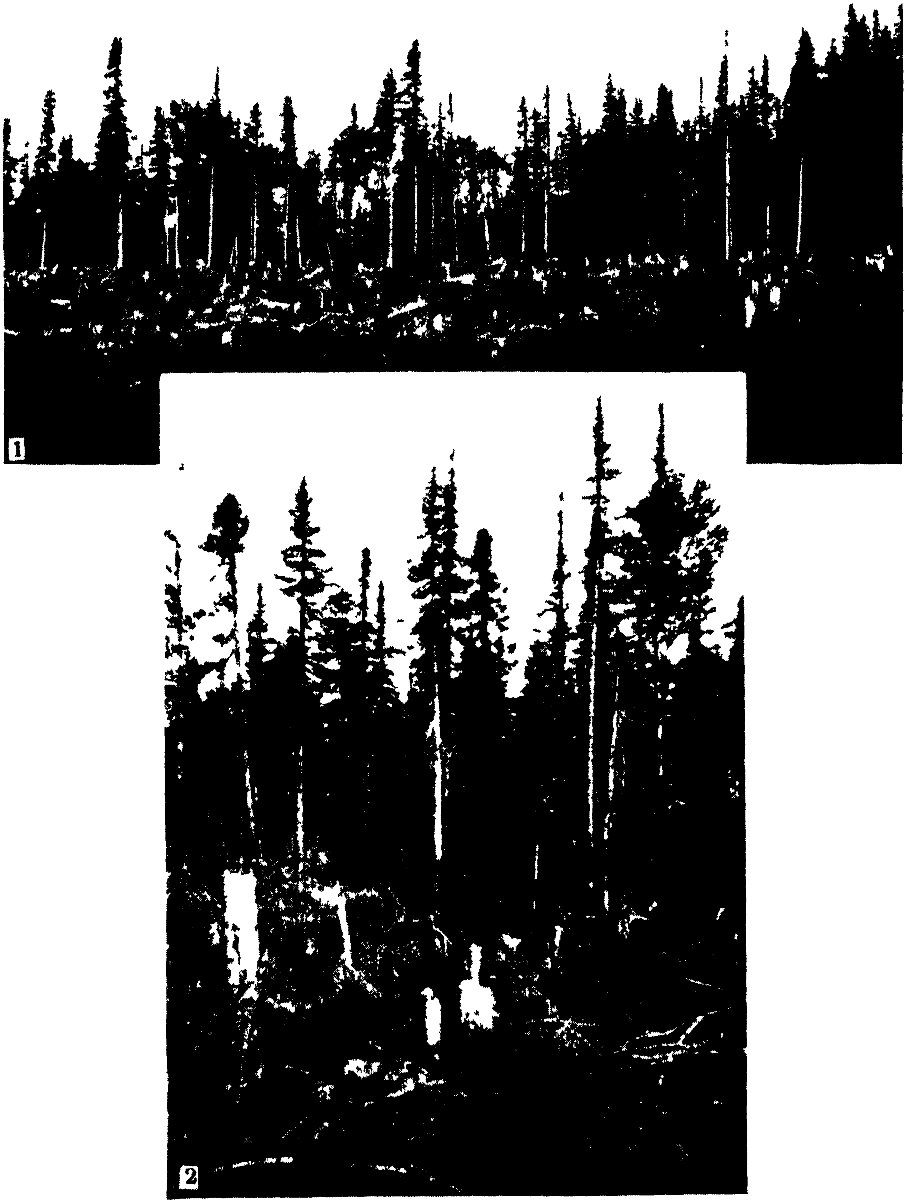
In general appearance, an outbreak of the hemlock looper in a balsam forest bears a close resemblance to a spruce budworm infestation; there are, however, certain differences. In the case of the looper outbreak on the North Shore, the defoliated areas were very irregularly distributed; for example, an area of balsam of ten or twenty acres might be completely defoliated and an adjacent area of the same type might be practically untouched. In a budworm outbreak, the infestation is generally much more evenly distributed over the whole district, almost every balsam showing some visible signs of feeding.

Outbreaks of the hemlock looper develop with extraordinary rapidity; almost without warning, enormous numbers of caterpillars appear, which under favourable circumstances, will completely strip the balsam of all sizes from young trees two or three feet in height to mature timber. This feeding will often result in the death of the stand within the year. The reproduction is often more severely injured than the larger trees; it is a common occurrence for trees from six to thirty feet in height to be killed, the smaller reproduction and merchantable timber being left living. Sometimes the second growth alone is affected, the young trees up to ten feet in height showing unmistakeable signs of feeding while the mature trees are apparently uninjured. This condition is more likely to occur in the early stages of an outbreak or in cases where the insect is present in small numbers but has not become epidemic.

Undoubtedly much of the injury to the tree is caused by wasteful feeding; the caterpillars do not, apparently, commence feeding on a leaf ane consume it entirely before passing on to the next leaf. In a heavily infested tree, almost every leaf will show signs of having been nibbled. Very often the feeding takes place at the extreme base of the needle, so that the leaf soon dies and becomes red in colour; this accounts for the characteristic red appearance of an infested forest, especially in the month of August; a closer examination reveals the presence of thousands of dead leaves, their bases gnawed off and remaining attached to the twigs by numerous strands of silk spun by the caterpillars. These festoons of dead and half eaten needles hanging from the twigs are very characteristic of an outbreak of the hemlock looper. Later in the fall, the dead leaves are removed to some extent by wind, rain and snow and the red appearance of the forest largely disappears.

### LIFE-HISTORY AND HABITS

The life-history of the hemlock looper is simple; the insect is single-brooded, the moths appearing in late August or in September and laying their eggs in the latter month. The eggs do not hatch until the following



*Figs 1 and 2.—Balsam defoliated by the hemlock looper.*

June, when the caterpillars are to be seen feeding on the leaves of their host-tree. Pupation occurs in early August, the moths appearing about two or three weeks later.

The eggs, which are deposited singly or in small groups of two or three, may be found almost anywhere; they have been found on the twigs of balsam, usually in the mass of silk and dead leaves left as a result of the feeding of the caterpillars. The female moths appear to show a preference for sites having some crack or crevice wherein to deposit their eggs; old cones are sometimes utilized, and trunks of trees, in crevices of the bark. The most favoured site for eggs appears to be in dry and decayed stumps and stubs; these are also the favourite places selected by the caterpillars for pupation. Eggs were to be found, often in numbers, in cracks and crevices of old spruce stumps which had been cut about thirty years before on one of the infested limits. This habit of egg-laying in old stumps probably explains why the young caterpillars in June and early July are to be found so abundantly on the reproduction.

The young larvae, on hatching, feed openly on the new foliage of the balsam and even on the small trees, there is a distinct tendency to congregate around the terminal shoot; as the caterpillars increase in size, they commence to ascend the larger trees; apparently they cannot recognize the favoured host-tree, as numbers of young caterpillars have been observed climbing up trees which had been dead for a number of years, as well as living spruce and birch. Although caterpillars are to be found feeding on the foliage at all levels, there is no doubt that they occur more abundantly in the upper branches; it might be said that 90% of the caterpillars on a balsam are to be found on the upper fifth of the tree. As the majority of the eggs are laid on sites near the ground, it is obvious that the reproduction suffers most from the early feeding; since the small trees and saplings almost invariably outnumber the mature timber, it can readily be seen that the caterpillars are more abundant on the smaller trees than on the mature timber.

The feeding of the caterpillars on the reproduction is generally only a temporary condition, as they always exhibit a tendency to climb the large trees. Mature caterpillars are to be found throughout the feeding period on the small tress but it is probable that they have become dislodged from other trees and have just settled on the reproduction prior to ascending the larger trees once more.

As a result of the wandering habits and restlessness of the caterpillars, it is difficult to estimate the population in a given area; experiments carried out in the spring of 1930 when the outbreak was decidedly on the decline, indicated an average population of over one million to the acre. This figure was arrived at by counting first stage caterpillars in a number of plots each ten feet square. Some of the plots contained old and decayed stumps and since these are the most popular sites for oviposition, the number of caterpillars taken from these plots was considerably in excess of the number from plots where these stumps were absent. One old stump about five feet in height yielded nearly three thousand caterpillars; many more probably had left the stump in search of food and others may have been overlooked.

In the North Shore outbreak, the favoured food-plant and the tree to suffer most from the ravages of the hemlock looper is the balsam fir (*Abies balsamea*). The hemlock (*Tsuga canadensis*) does not occur on the North Shore. Both white spruce and black spruce, especially the reproduction, are also fed upon, but no instances were observed in which trees of these species were totally defoliated or killed, although white spruce has been reported killed by the hemlock looper in Newfoundland. In the early stages, the caterpillars are found feeding on all kinds of small vegetation such as *Amelanchier*, *Acer rubrum*, *A. spicatum*, *Vaccinium* and *Cornus*. Older caterpillars are sometimes found on birch but their presence is probably only casual as these trees have not been defoliated to any appreciable extent even when situated in a heavily defoliated stand of balsam. Under cage conditions, third stage caterpillars were successfully brought to maturity on a diet of birch foliage.

It has been proved conclusively in a number of experiments that first stage caterpillars cannot subsist on the old growth of either spruce or balsam; caterpillars provided with such foliage made no attempt to feed and invariably died of starvation or else were devoured by their neighbours. Experiments carried out with a view to determining the maximum length of time first stage caterpillars can live without feeding were productive of some interesting results. In no instance were caterpillars observed to survive more than four days starvation, the majority dying on the second and third days. There is no doubt that caterpillars when caged in vials without food do not hesitate to feed upon each other. Cannibalism was evident in nearly all experiments where starvation studies were being carried out; it was also noticed when caterpillars were provided with unsuitable food-plants such as the old foliage of spruce or balsam. The table submitted below will serve to show the rate of death among caterpillars when confined in vials without food. A somewhat similar mortality rate was obtained when young caterpillars were confined with the old foliage of spruce or balsam, so that the absence of humidity in the vials containing no food-plant whatever had little or no influence on the death of the caterpillars.

TABLE 1.—LONGEVITY TESTS OF FIRST STAGE CATERPILLARS COLLECTED JUNE 18 AND CAGED IN VIALS WITHOUT FOOD. TEN CATERPILLARS PLACED IN EACH VIAL

| Day of death | Number of dead caterpillars. Vial number | | | | | | | | | | Total number dead |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | |
| Second day | 4 | 8 | 9 | 9 | 7 | 8 | 7 | 8 | 9 | 8 | 77 |
| Third day | 6 | 2 | 1 | 0 | 3 | 2 | 1 | 2 | 1 | 2 | 20 |
| Fourth day | – | – | – | 1 | – | – | 2 | – | – | – | 3 |

N.B.—
77% were dead on the second day.
97% were dead by the third day.
100% were dead by the fourth day.

In all starvation and similar experiments a separate series of caterpillars was being reared with young balsam foliage under similar conditions; these caterpillars made satisfactory progress, so that the heavy mortality observed in other experiments could not be attributed to unsatisfactory rearing conditions. The complete mortality of hemlock looper caterpillars on the fourth day of starvation is in marked contrast to the spruce budworm; similar experiments carried out with this species showed that 50% of the caterpillars were living on the fourth day of starvation and that one remained alive for eleven days.[2] The inability of the young caterpillars to survive long periods without feeding is probably of considerable importance in the successful application of artificial control by means of clean cutting; this is discussed later.

Pupation takes place towards the end of July or in the first week of August according to season; the pupae are to be found almost everywhere; specimens have been taken quite exposed on the twigs at the tops of the trees and on the lower branches. They are often abundant in crevices of the bark, among the lichen on the trunk and often occur in numbers behind a loose piece of bark. Other sites are on the ground without any covering whatever, sometimes just below the surface litter or sheltered by a chip or leaf. The most popular resorts, however, were dry, decayed, and heavily checked stumps or stubs. The caterpillars not infrequently entered deep checks and pupated in the wood at a depth of two inches or more. If the decayed wood was inclined to be damp, the numbers of pupae to be found therein were comparatively small.

Emergence of the moths takes place generally in the month of September; the males are the first to appear, the peak emergence period of this sex being about a week in advance of the corresponding period of the females. The insects may be seen flying at all hours, though activity becomes more pronounced towards the evening. The males are attracted to light. The moths are eager for moisture and are often to be seen in numbers on patches of mud or wet sand. They also drop readily into water; when the insects are very abundant, the surfaces of lakes and rivers are often covered with their bodies.

The flight habits of the hemlock looper were studied in some detail in September 1929 in one locality where the insects were fairly plentiful. On warm days the males were to be seen flying everywhere and in every direction and there was nothing observed which might indicate that the moths were swarming from one locality to another; all the flights appeared to be aimless. Very few females were observed flying except when disturbed. The powers of flight of both sexes are apparently feeble. A noticeable feature in connection with the flight habits is that the moths seldom fly high; when at rest on the trunks of trees, they are always more abundant on the lower ten feet than on any other part, though a few moths can generally be dislodged from the upper trunk and branches by jarring the tree. The moth flight is generally over by the end of September; if the weather is not too severe, occasional specimens may be encountered up to the middle of October.

## TYPE OF FOREST AFFECTED

The forest in which the infestations occurred is almost wholly a balsam-spruce type; the balsam is the predominant species and occurs frequently in pure stands with occasional white spruce of large dimensions or mixed with black spruce. Towards the tops of the hills and mountains or on poor soil, the black spruce becomes more in evidence. Swampy areas are also usually of a pure black spruce type. The hardwoods are poplar and white birch; the former is usually associated with old burns and the latter is more or less evenly distributed throughout the mature forest, becoming more plentiful along the river valleys and also associated with poplar in the burns. Jack pine occurs locally in pure stands but is not very widely distributed; it seems to be more prevalent along the coast line than inland. White pine, which is scattered here and there throughout the forest, does not often reach commercial size and is frequently gnarled and twisted so as to be of little value.

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[2] Studies on the Spruce Budworm. Bull 37, N.S. Dom. Dept. Agr. Ottawa, 1924.

It was observed that the injury on the North Shore was, on the whole, more severe in pure stands of balsam than in mixed forest; severe defoliation of balsam has occurred, however, in stands containing up to 45% of spruce, calculated on the number of trees in the stand. In the North Shore outbreak, the spruce have not been severely injured with the exception of small trees growing in heavily infested stands of balsam; the larger spruce (8″ d.b.h. and over) appear to have been untouched even when surrounded by infested balsam. Wherever the small spruce have been attacked, the injury has generally been more severe on the white spruce, (*Picea canadensis*) than the black spruce (*Picea mariana*).

## ORIGIN OF OUTBREAKS

There is as yet no positive information as to the origin of hemlock looper outbreaks such as have occurred recently; the insect is native to North America and the nature of the infestations on the North Shore suggests that the outbreaks have arisen spontaneously over a number of districts, often widely separated. There is no reason to believe that the North Shore infestation developed from one central area and then spread outwards; there is certainly nothing to suggest that the outbreak originated from a flight of moths which had somehow drifted in from some distant infested region. The simultaneous appearance of all the infested areas, often completely isolated, dispels the theory at once; it is obvious that the Pentecost outbreak cannot be connected with the infestation at Manicouagan which is 75 miles further west; between these points there are a number of other infested regions but there are also large tracts of uninfested balsam.

The irregular distribution of the infestations, appearing as they do, haphazard throughout a large area of forest of more or less uniform composition, certainly suggests very strongly that all the outbreaks are entirely independent of one another. The most interesting feature in connection with these outbreaks is that there is little, if any, spread; although enormous numbers of eggs had been laid in the fall of 1928, the year of greatest abundance, the outbreak showed a marked decline in virulence in 1929; there had been certainly no apparent spread of the insect in that year from the infested areas of 1928 to the neighbouring stands of healthy balsam in 1929. It is probable that the feeble flight of the moths helps to prevent to some extent a rapid spread from one locality to another.

## WINTER KILLING

Balsam fir completely defoliated in the summer generally die in the following winter and spring. If defoliation is not complete, the trees will generally bud out again and, if subjected to no further injury, will probably continue to live. This condition is apparent over a large section of the Trinity-Calumet-Marée infestation. The 1928 feeding, though severe, did not cause complete defoliation everywhere; many of the trees have budded out well and as the outbreak has apparently subsided, there is no reason why these trees should not continue to live, since the only serious secondary insect, *Monochamus marmorator* Ky., appears to be decidedly scarce throughout the infested district.

## LOSS OF INCREMENT

The outbreak of the hemlock looper developed with such rapidity that there is no apparent reduction of ring growth except for the years 1929 and 1930, which can be attributed to the 1928 and 1929 feeding respectively. A number of trees heavily attacked in 1928 were examined in the fall of that year but there was no evidence of any suppression of the current years' growth; the full effect of that year's feeding was not apparent until 1929 when it was found that the 1929 ring was much reduced even in those trees which did not experience any further defoliation in that year. The growth of the spruce remained normal. An examination of a number of balsam stumps from 75 to 100 years of age failed to yield any evidence of previous outbreaks; reductions in growth were apparent on most trees, but not at identical periods.

Further studies on the ring growth were made at Pentecost and Trinity in 1930; cores were taken from infested balsam in a number of localities, and as a check, a number of cores were taken from some uninfested balsam. The annual radial growth for the last ten individual years was taken from each sample and the averages recorded as shown in Figure I.

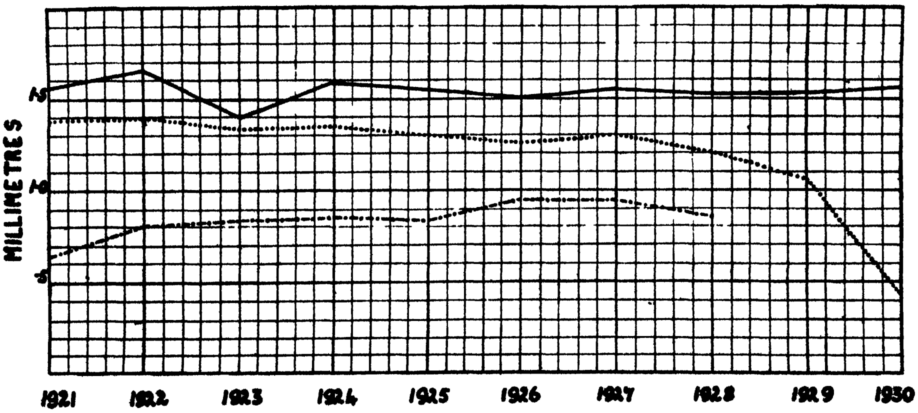

*Figure 1.—Average Annual Radial Increment of Balsam*

*Uninfested Balsam, Pentecost Lake*................ ————————

*Infested Balsam, Pentecost Lake (1928-29)*......... ..............

*Balsam killed in 1928, Trinity River*.............. —·—·—·—

The only marked reduction in the growth appears in the samples from Pentecost lake; the status of the outbreak in this district in 1928 was unknown, it was severe in 1929, and comparatively light in 1930. The 1930 ring in this series was, on the average, decidedly small, apparently indicative of the heavy feeding in 1929. The growth rings from the uninfested balsam, also taken from Pentecost, were remarkably uniform, varying less than one tenth of a millimetre from 1924 to 1930 inclusive. The higher average growth of this series may probably be attributed to the fact that the trees were growing on rich, alluvial soil.

The third series from the Trinity river was from trees known to have been killed in the winter 1928-1929, following heavy feeding in 1928. There is no evidence from the cores that would suggest several years of feeding previous to 1928; the growth in the year of death was as rapid as in 1921, 1920 and 1919. The comparatively slow growth of the Trinity samples is doubtless due to the fact that the trees from which the cores were taken were growing in a muskeg type, associated with black spruce.

## SECONDARY INSECTS

Other insects attacking the weakened and dying balsam were not as abundant as might be expected. Secondary insects have sometimes played an important part in some of the recent spruce budworm outbreaks and their presence was naturally anticipated in the North Shore infestation. The usual secondaries such as the balsam bark-beetle (*Pityokteines sparsus* Lec.) and the balsam bark-weevil (*Pissodes dubius* Rand.) were evenly distributed throughout the infested area but had not become sufficiently plentiful to threaten the recovering balsam; even on dying trees, the secondaries were far from being abundant.

Up to 1930, there were no apparent indications of any secondary insect affecting trees which were not already showing signs of impending death as manifested by a yellowing of the foliage or a discoloration of the cambium.

The balsam sawyer (*Monochamus marmorator* Ky.) appears to be decidedly scarce on the North Shore, only one specimen being observed throughout the summers of 1929 and 1930. This species although rarely seen in districts where it occurs quite commonly, breeds exclusively in balsam and has caused considerable injury in some parts of the country by killing off the recovering balsam some years after the subsidence of spruce budworm outbreaks. All *Monochamus* larvae removed from dying balsam on the North Shore proved to be those of an allied species, *M. scutellatus* Say, the well-known black sawyer beetle.

Since the spruce have not been affected at all, the swarms of bark-beetles usually associated with these trees need not be taken into consideration.

## CONTROL

*Natural Control.*—The North Shore outbreak caused greatest injury in the year 1928; in the following year (1929) it had practically subsided with the exception of a few areas at Pentecost; even there the degree of injury was considerably less than that sustained in 1928. By 1930, the outbreaks had subsided almost completely and all that was left to indicate the infestation were the dead and dying balsam which had suffered severe injury in the previous years. The cause of the decline is not yet apparent. There is no evidence that the factors of starvation, parasites, disease, predatory birds or insects, had any influence whatever in reducing the numbers of the insect to what is virtually its normal state of abundance. It seems highly probable that the sudden decline can be attributed to the abnormally wet summers of 1929 and 1930. There is not much evidence in support of this theory beyond the fact that the summer of greatest abundance (1928) was both hot and dry, and that the succeding years were decidedly wet. In the course of experiments with young caterpillars, it was observed that a slight condensation of moisture in the breeding cages resulted in the death of a large percentage of the number of the occupants.

*Artificial Control.*—There are two methods of artificial control which may be considered feasible; the first is aerial dusting with calcium arsenate or other suitable stomach poison. This method has been proved satisfactory over small, isolated areas where the comparatively high cost has been justified not only in the value of the timber that has been saved, but also taking into consideration the prevention of possible spread over a much larger area. Aerial dusting cannot yet be considered practical in dealing with infestations which may cover large areas of fifty square miles or more. Although aerial dusting has been proved satisfactory against the hemlock looper, there is undoubtedly a great element of chance in its successful application; unsatisfactory weather conditions at the time of dusting or heavy rains immediately after the dust has been applied, and the danger of accidents are important factors that must be taken into consideration when a dusting project on a commercial scale is undertaken.

The alternative method of artificial control is the logging of the infested district. By a system of clean-cutting, the advantages are two-fold. Firstly, the dead and dying merchantable balsam are at once utilized before decay sets in which would render the wood unfit for pulping purposes; secondly, a clean-cutting operation involving the removal of all balsam four inches on the stump and over, would cause the probable destruction, through starvation, of enormous numbers of caterpillars in the following spring. A clean-cutting operation on the lines described above would not leave much timber standing except the birch and the small reproduction. It has been proved in the course of the biological studies outlined in a previous paragraph, that the young caterpillars on hatching from the eggs in the spring cannot live for more than four days without food; that being the case, the caterpillars would have to subsist on the limited amount of new foliage on the reproduction or else migrate to an uncut area. While no actual figures are available on this subject, it would appear highly improbable that the reproduction left after a clean-cutting operation could sustain the caterpillars especially when they are very abundant. It is also difficult to imagine swarms of caterpillars about one sixteenth of an inch in length travelling over acres of slash into fresh feeding grounds. The old foliage remaining attached to the branches and tops of the felled trees would not serve as a temporary food-plant, as experiments have shown that the young caterpillars will not feed on the old foliage of either spruce or balsam. It is unlikely, therefore, that there would be sufficient food left to bring the caterpillars to maturity, unless the reproduction left after logging were exceptionally thick.

As a control measure, the cutting method has its disadvantages; obviously it cannot be adopted on unleased Crown lands; even on leased limits, the facilities for handling large quantities of wood at very short notice may be inadequate or even totally absent.

## RÉSUMÉ

UN COMPTE RENDU DE L'ARPENTEUSE DE LA PRUCHE DE L'EST, *Ellopia Fiscellaria* Gn., SUR LE SAPIN BAUMIER. E. B. Watson, Division Fédérale de l'Entomologie, Ottawa, Ont.

L'arpenteuse de la pruche (Hemlock looper) s'est montrée un fléau destructeur du sapin baumier dans le Québec en ces dernières années. Des invasions de cet insecte se sont produites en 1928 sur la rive nord du Golfe St-Laurent. Ce sont les chenilles qui causent les dégâts; elles se nourrissent des feuilles du sapin baumier; les arbres meurent souvent au bout d'une année de défeuillaison. Les œufs sont pondus par les papillons femelles en septembre mais ils n'éclosent qu'en juin de l'année suivante. Les larves se nourrissent en juillet, elles se transforment en chrysalides en août et les papillons apparaissent bientôt après. Les moyens répressifs recommandés sont le saupoudrage par aéroplane avec l'arséniate de calcium et l'enlèvement des débris après l'abatage des arbres. Ce dernier moyen doit être préféré, car le bois mort est utilisé immédiatement avant que les détériorations se manifestent; de même les chenilles qui éclosent au printemps ne trouvent plus d'arbres sur lesquels elles peuvent se nourrir et meurent de faim.

# OBSERVATIONS ON THE BROWN HEART DISEASE OF TURNIPS[1]

R. R. HURST[2]

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## INTRODUCTION

Turnip brown heart, although known to the farming industry, was not thought to be economically important in Prince Edward Island. About 1928 this disorder occasioned considerable financial loss to the farmers throughout the province, many car loads of turnips being useless, while in the spring of 1929 it was a common sight to see fields of affected turnips which had been abandoned the previous year. Subsequently it was learned that brown heart constitutes a problem of major importance, as shipping point rejections are estimated to exceed an annual value of $50,000.

The few references in the literature available to the writer indicate that brown heart has not received the attention which its present importance would seem to justify. In Canada it was first mentioned in 1910, by the Dominion Botanist (1) who referred to it before the Select Standing Committee on Agriculture and Colonization. In 1913 Woods (2) of Maine investigated what appears to have been the same disorder which he mentions under the name of "Black heart."

## THE NAME

Brown heart of turnips has been frequently referred to as water core, black heart, water heart, punky core, and woody centre. These names, however, are sufficiently descriptive to identify the condition referred to, for the symptoms suggesting the various terms are present in affected turnips at one time or another to a greater or less degree. The name brown heart, which seems quite appropriate, originated among the farmers of Prince Edward Island where it has become established.

## SYMPTOMS

Brown heart may be found in turnips ranging in size from seedlings to large roots. The only method known to the author of detecting its presence is to cut into the turnip. Some observers have stated that roots affected by this disorder exhibit a cracking of the tissues in the region of the neck; others express the belief that "long neck" in turnips is an indication of brown heart. Neither of these conclusions has been supported by our observations. Brown heart does not increase in storage, but turnips badly affected by brown heart are found to be lighter in weight as compared with sound ones after a storage period of several weeks.

On making a transverse cut through an affected turnip, (Figure 1) brown heart is readily recognized as a clearly defined brownish and mottled central area, which shows up in sharp contrast with the lighter coloured surrounding tissues, but which does not extend outwards past the layer of cambium. The freshly cut surface of these turnips appears glassy, or watersoaked, (Figure 2) which has given rise to the name of "water core" for the disorder. In transverse sections turnip brown heart may be further recognized by the very frequent occurrence of concentric light and dark rings and when exposed to the air the darker portions rapidly become sunken while the lighter (normal) tissue retains its firm texture. When cut longitudinally (Figure 3) the affected area is shown to follow the fibrous tissue and to converge towards the base of the turnip.

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[1] Contribution from the Division of Botany, Experimental Farms Branch, Dominion Department of Agriculture, Ottawa, Canada. Presented at the meeting of the Canadian Phytopathological Society held in connection with the World's Grain Exhibition and Conference, Regina, Canada, July 25, 1934.

[2] Plant Pathologist in charge.

Brown heart when present, most commonly affects one-half to three-quarters of the turnip, but in large specimens an affected area not more than one inch in diameter is frequently found. As turnips advance in age (in storage) the brownish character generally becomes less pronounced and the mottling may disappear entirely, leaving a greyish brown, dry, punky mass composed of dried out and broken down cellular tissue (Figure 4).

The palatability of brown heart turnips has been tested, and it can be stated definitely that either raw or cooked they are decidedly bitter to the taste. This observation applies only to the discoloured tissues. In addition, affected turnips when cooked are found to be distinctly woody.

## CAUSE

There is nothing to suggest that brown heart is of parasitic origin. Nevertheless many attempts have been made in the laboratory to isolate a pathogenic organism from the affected tissue. Failure in this respect led to the conclusion that it is entirely of a physiological nature. This view was substantiated by observations in the field and further supported by opinions expressed in correspondence.

Pursuing the possibilty of virus infection a number of tests were conducted as follows:

*Rubbing.*—Tissue from affected turnips was rubbed on (a) the leaves (b) the scarified surface of the roots of sound turnips. All the plants were grown under insect-proof cages and upon examination at the end of the growing season showed no indication of brown heart.

*Filtered juice from affected areas.*—On August 8, 1931 the undiluted filtered juice from affected turnips was injected into turnips which were grown under insect-proof cages, the inoculated plants being examined October 1st. There was no evidence of brown heart in the inoculated turnips. Referring to the possible virus nature of brown heart Mr. D. J. MacLeod, Plant Pathologist at Fredericton reports as follows: "In so far as the work on the virus nature of brown heart is concerned we have not been able to establish, either from tests conducted last winter or this summer, any evidence of brown heart being due to a virus."

## INVESTIGATIONAL WORK

### DISTRIBUTION

The occurrence of brown heart has been reported* in Denmark, England, Ireland, the United States (Massachusetts and Maine), and Canada (British Columbia, Ontario, Quebec, Nova Scotia, New Brunswick, and Prince Edward Island). It would seem, therefore, that the trouble

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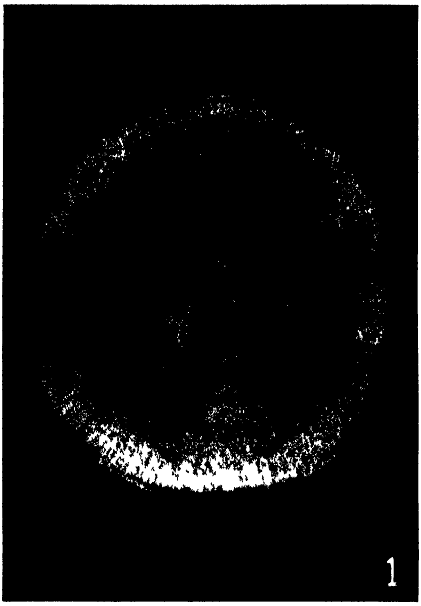
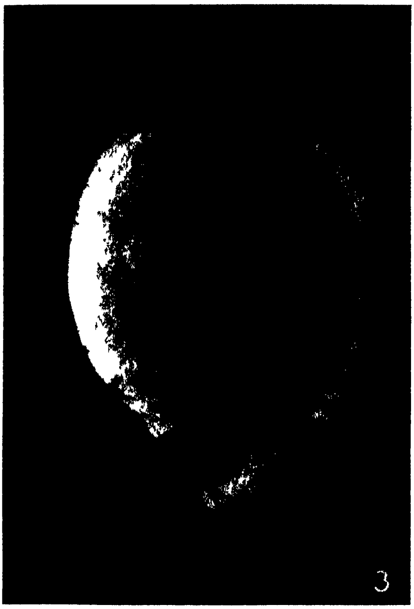
*Information gathered largely through correspondence.





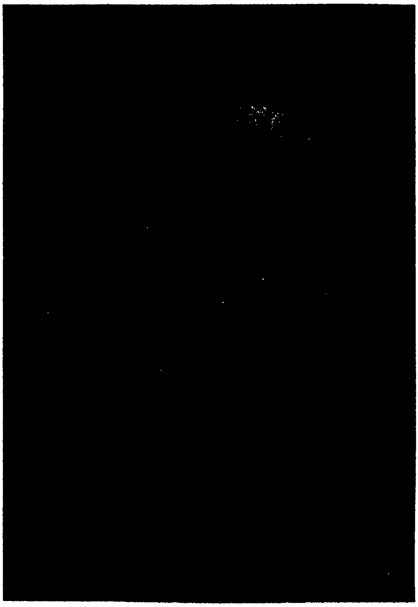


*Figure 1. Brown heart of turnips. This section was cut across the lower end of a large turnip.*

*Figure 2. Brown heart of turnips. Note the water-soaked appearance and clearly defined light and dark concentric rings.*

*Figure 3. Brown heart of turnips showing the nature of symptons in a turnip cut longitudinally.*

*Figure 4. Brown heart of turnips showing advanced stage.*

is very widely distributed. Furthermore, it has been known to be troublesome for many years in Canada and Europe. Writing in this connection from British Columbia one correspondent stated—"For over 20 years the Swedish turnips that I have grown have been affected every year with this trouble in varied degrees so that I could never be sure of having more than 50% that I could ship to Vancouver for table use with certainty that they were free from this internal trouble."

While widely distributed in Prince Edward Island its occurrence has not been reported from the farming country designated as the "North Shore", which extends from North Point to East Point. Similarly, it is uncommon in the extreme westerly section of the province where three cases only have been recorded. In the rest of the provinces, it appears sporadically, cropping up here and there, and, what is more striking, in spots or stretches in a field of turnips otherwise free from brown heart. These findings have been established by a province-wide survey conducted during the past two years (Figure 5).

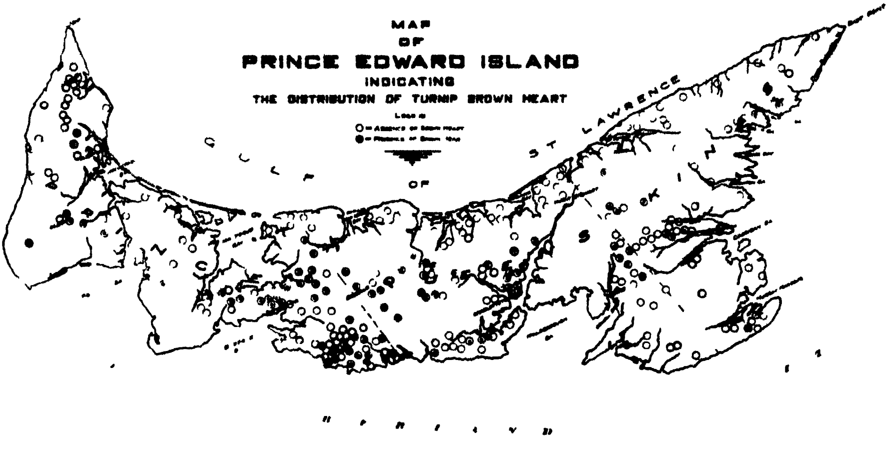

MAP
OF
PRINCE EDWARD ISLAND
INDICATING
THE DISTRIBUTION OF TURNIP BROWN HEART
Legend
○ = Absence of Brown Heart
● = Presence of Brown Heart
GULF
OF
ST. LAWRENCE

Figure 5

## VARIETAL SUSCEPTIBILITY

In 1931 varietal reaction to turnip brown heart was studied at Experimental Stations located as follows: Charlottetown, P.E.I.; Kentville and Nappan, N.S.; Cap Rouge and Lennoxville, Que.; and Rosthern, Sask. The varieties represented included all those offered for sale in Canada besides numerous strains and varieties secured from shipments in the spring of 1931. The data gathered from this source failed to reveal any varieties possessing immunity to brown heart, but it was noticeable that certain ones were more severely attacked than were others.

In 1932 the experiments were continued at Charlottetown with interesting and possibly important results for, out of twenty varieties tested, absolute freedom from brown heart was exhibited by four strains of turnips namely:

Metts Bangholm (Godfrey).
Halls Westbury (Ewing).
Good Luck (Steele Briggs).
Carters Purple Top Swede.

The experimental plan giving rise to this observation comprised four widely separated replications of each of the twenty varieties represented, all of which were attacked by brown heart with the four exceptions noted above. Woods (2) expressed the opinion that strains exhibit differences in susceptibility to the trouble, basing his belief on the evidence that one variety grown under test was entirely free from what he termed, "black hearted" roots. The four varieties grown by him were: Carters Imperial, Skiwings Purple Top, White Egg, and Golden Neckless. The last named was the one entirely free from the trouble.

## EFFECT OF MANURE ON BROWN HEART

In the course of routine observations it was discovered that turnips were free from brown heart when grown on the former sites of manure piles. This observation was tested experimentally in 1932. In a section

TABLE 1.—EFFECT OF MANURE ON BROWN HEART, IN A FIELD TRIAL IN 1932

| Row number | Turnips on site of manure pile | | | Turnips not on site of manure pile | | |
|---|---|---|---|---|---|---|
| | Number affected with brown heart | Total number turnips | Percentage affected with brown heart | Number affected with brown heart | Total number turnips | Percentage affected with brown heart |
| 1 | 1 | 10 | 10.0 | 6 | 88 | 6.8 |
| 2 | 3 | 9 | 33.0 | 17 | 97 | 17.5 |
| 3 | 0 | 7 | 0.0 | 21 | 89 | 23.6 |
| 4 | 0 | 9 | 0.0 | 23 | 88 | 26.1 |
| 5 | 0 | 11 | 0.0 | 17 | 94 | 18.1 |
| 6 | 0 | 9 | 0.0 | 13 | 93 | 14.0 |
| 7 | 0 | 11 | 0.0 | 11 | 94 | 11.7 |
| 8 | 0 | 12 | 0.0 | 18 | 97 | 18.5 |
| 9 | 0 | 11 | 0.0 | 24 | 95 | 25.3 |
| 10 | 1 | 12 | 8.3 | 28 | 95 | 29.5 |
| 11 | 1 | 11 | 9.1 | 21 | 96 | 21.9 |
| 12 | 0 | 11 | 0.0 | 11 | 93 | 11.8 |
| 13 | 1 | 12 | 8.3 | 25 | 94 | 26.6 |
| 14 | 1 | 50 | 2.0 | 12 | 51 | 23.5 |
| 15 | 1 | 50 | 2.0 | 19 | 49 | 38.8 |
| 16 | 0 | 53 | 0.0 | 25 | 48 | 52.1 |
| 17 | 1 | 55 | 1.8 | 24 | 51 | 47.0 |
| 18 | 0 | 55 | 0.0 | 27 | 54 | 50.0 |
| 19 | 0 | 51 | 0.0 | 28 | 54 | 51.8 |
| 20 | 2 | 55 | 3.6 | 34 | 54 | 63.0 |
| 21 | 2 | 53 | 3.8 | 29 | 51 | 56.9 |
| 22 | 1 | 10 | 10.0 | 30 | 92 | 32.6 |
| 23 | 0 | 7 | 1.0 | 32 | 94 | 34.0 |
| 24 | 1 | 10 | 10.0 | 31 | 99 | 31.3 |
| 25 | 0 | 10 | 0.0 | 9 | 99 | 9.1 |
| Total | 16 | 594 | 2.6 | 535 | 2,009 | 26.6 |

of land approximately three-quarters of an acre in area, two manure heaps were placed, one in 1930, the other in 1931. Each heap occupied a space 70 feet long by 25 feet wide, both intersecting to form a right angle. The former was removed in the spring of 1931, the latter in 1932, when the entire plot was seeded to turnips in rows 30 inches apart. This particular field had received no commercial fertilizer for many years and in 1929 produced a crop of turnips badly affected with brown heart. When recording results at the end of the growing season, every turnip in the entire plot was examined critically for evidence of brown heart.

By consulting Table 1 it will be seen that brown heart was consistently absent where the rows crossed the former sites of the two manure heaps.

## EFFECT OF VARYING AMOUNTS OF MANURE ON BROWN HEART

An extensive survey of the turnip fields throughout the province in 1932 yielded data confirming our previous findings that in general the amount of brown heart decreased as the applications of manure were increased regardless of variations in the quantities and kinds of fertilizers used. In the entire absence of manure, brown heart was usually present in amounts ranging from 25 to 90 per cent, a distinction which has found practical significance on those dairy farms which have been favoured for many years by the availability of barnyard manure in abundance.

The effect of different amounts of manure was studied further in a series of pot tests using well rotted manure at nine different rates, as shown in Table 2.

Ten pots were filled with each mixture, the seeds were sown on June 10th, and on November 1st each turnip was examined for indications of brown heart. The results are given in Table 2.

TABLE 2.—THE EFFECT OF DIFFERENT AMOUNTS OF MANURE ON BROWN HEART WHEN THE MANURE IS ADDED TO A SOIL KNOWN TO HAVE PRODUCED AFFECTED TURNIPS THE PREVIOUS YEAR

| Rate of application Tons per acre | Number of brown heart Turnips | Per cent brown heart turnips |
|---|---|---|
| Check (no manure). | 2/10* | 20.0 |
| 5 | 1/10 | 10.0 |
| 10 | 2/8 | 25.0 |
| 15 | 0/10 | 0.0 |
| 20 | 2/10 | 20.0 |
| 25 | 1/10 | 10.0 |
| 30 | 0/10 | 0.0 |
| 35 | 0/10 | 0.0 |
| 40 | 0/10 | 0.0 |

* The denominator indicates number of turnips examined.

## DATE OF SEEDING IN RELATION TO BROWN HEART

It has been intimated repeatedly that seeding dates have a direct bearing upon the development of brown heart, a theory discussed prominently by farmers, some of whom claim that early seeding is the predisposing factor. In 1931, field observations substantiated this view in a measure, yet the irregularity of actual findings indicated the existence of certain unknown influences operating to induce brown heart regardless of the seeding dates.

When this supposition was tested experimentally, brown heart was found to be most abundant in the later seedings. This phase was subjected to a very careful study in 1932, using five different varieties with each represented by six seeding dates as follows: June 9th, June 19th, July 5th, July 15th, July 25th and August 5th. The results of the experiment are given in Table 3.

TABLE 3.—DATE OF SEEDING IN RELATION TO BROWN HEART
(Examinations completed November 5, 1932)

| Seeding date | Variety | | | | | Total number brown heart turnips |
|---|---|---|---|---|---|---|
| | Bang-holm | Haszards improved | Mill-Pond | Grey-stone | Mammoth | |
| June 9 | 2/52* | 0/35 | 3/39 | 0/18 | 0/30 | 5 |
| June 19 | 1/63 | 3/35 | 1/34 | 1/12 | 1/23 | 7 |
| July 5 | 2/44 | 2/130 | 0/46 | 0/59 | 1/63 | 5 |
| July 15 | 1/79 | 1/170 | 0/71 | 0/43 | 1/51 | 3 |
| July 25 | 1/56 | 2/137 | 0/65 | 0/27 | 0/42 | 3 |
| Aug. 5 | 0/67 | 2/127 | 5/130 | 0/67 | 0/63 | 7 |

* The numerator gives the number of affected turnips the denominator, the number examined.

Stated briefly, the most brown heart came from the second and sixth seedings. First and third seedings were next in order while four and five were practically free from brown heart.

## SOIL REACTION STUDIES

Hydrogen-ion concentration tests were made in connection with the field experiment on the effect of manure on brown heart. The field in question was marked off crosswise into ten zones in such a manner as to include a section of every row; thus 75 pH tests were made in each zone and the values correlated with the actual intensity of brown heart as determined by the examination of each turnip within that area. The results were recorded in Table 4.

From the foregoing tabulation it is obvious that the severity of brown heart does not appear to be correlated with soil reaction as expressed in pH values. Considering, however, only the actual field run of soil reaction test, it was observed that turnips from soil having the highest phH values were free from brown heart. Furthermore, such turnips were of a superior quality.

TABLE 4.—THE EFFECT OF SOIL REACTION ON BROWN HEART

| Zone number | Total number turnips in zone | Total number brown heart turnips | Per cent brown heart | Average pH value |
|---|---|---|---|---|
| 1 | 207 | 55 | 26.57 | 7.080 |
| 2 | 261 | 110 | 42.14 | 6.885 |
| 3 | 243 | 156 | 62.20 | 7.168 |
| 4 | 192 | 66 | 34.37 | 7.136 |
| 5 | 159 | 9 | 5.66 | 7.020 |
| 6 | 142 | 8 | 5.63 | 7.032 |
| 7 | 265 | 20 | 7.55 | 7.010 |
| 8 | 382 | 29 | 7.59 | 6.742 |
| 9 | 449 | 44 | 9.80 | 6.621 |
| 10 | 308 | 54 | 17.55 | 6.775 |

## SUMMARY

Turnip brown heart, a physiological disorder, has been under investigation since 1928 when it was found to be responsible for annual losses in Prince Edward Island amounting to not less than $50,000. The name brown heart has been established through usage in the rural communities although it has been appropriately referred to in America and Europe as black heart, water core, water heart, punky core and woody centre. Typical symptoms are found in turnips ranging in size from seedlings to large roots, the only known method of detecting its presence being to cut into the turnip. It does not increase in storage, neither does it cause a rot although badly affected specimens become noticeably lighter in weight when stored for several weeks. Brown heart is recognized as a clearly defined brownish and mottled central area further characterized in freshly cut turnips by a glassiness and water-soaked appearance with concentric light and dark rings. Turnips thus affected have a decidedly bitter taste and when cooked are found to be distinctly woody. Brown heart has been found in Europe as well as in the United States and Canada. It is widely distributed in Prince Edward Island, but does not occur to any extent along the north side of the Island. Varietal tendencies have been noted and four different strains were found to be immune in 1932. With increased manure applications the disease decreased; and it failed to develop on the former sites of manure heaps. No significant difference has been determined experimentally with respect to seeding dates nor does the presence or absence of the disease appear to be critically correlated with soil reaction.

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2. WOODS, CHAS. D. Black-heart disease. Bull. 236, Maine Agr. Exp. Sta. p. 57. 1915.

## . RESUME

OBSERVATIONS SUR LE CŒUR BRUN DES NAVETS. R. R. Hurst, Laboratoire fédéral de pathologie végétale, Charlottetown, I.P.-E.

Le cœur brun des navets, une maladie physiologique, est l'objet de recherches depuis 1928; on a constaté qu'il cause tous les ans dans l'Ile du Prince-Edouard des pertes qui se montent à plus de $50,000.' Le nom "Cœur brun" a été établi par l'usage dans les groupements ruraux, mais en Amérique et en Europe la maladie est connue sous d'autres noms et qui paraissent également appropriés, tels que cœur noir, cœur aqueux, cœur d'eau, cœur pourri et cœur liégeux. On a trouvé des symptômes typiques dans les navets, dans toutes les phases de la végétation, depuis la phase de la plantule jusqu'à la racine entièrement développée. Le seul moyen de découvrir la maladie est d'entailler les navets. La maladie n'augmente pas en cave; elle ne cause pas non plus de pourriture, mais les navets très affectés perdent beaucoup de poids au bout de plusieurs semaines de conservation. Dans le cœur brun la partie centrale du navet est brunâtre et tachetée. Les navets fraîchement coupés ont aussi une apparence imprégnée d'eau, et exhibent des cercles concentriques clairs et foncés. Les navets ainsi affectés ont un goût très amer et quand on les fait cuire ils sont tout à fait liégeux. Le cœur brun a été constaté en Europe ainsi qu'aux Etats-Unis et au Canada. Il est très répandu dans l'Ile du Prince-Edouard mais beaucoup moins sur la côte nord de l'Ile qu'ailleurs. Les variétés y sont plus ou moins sujettes. Quatre espèces différentes se sont montrées réfractaires en 1932. Lorsque la quantité de fumier était augmentée, la maladie diminuait, et la maladie ne s'est pas développée sur les emplacements d'anciens tas de fumier. Aucune différence significative n'a été déterminée expérimentalement en ce qui concerne les dates de semailles, et il ne paraît y avoir aucune relation entre la réaction du sol et la présence ou l'absence de la maladie.

# THE ECONOMIC SITUATION

PREPARED IN THE AGRICULTURAL ECONOMICS BRANCH, DEPARTMENT OF AGRICULTURE, OTTAWA, LARGELY FROM DATA COMPILED IN THE DOMINION BUREAU OF STATISTICS

Wholesale prices in Canada advanced in June, the index rising from 71.1 in May to 72.1. A rather substantial gain was registered in the vegetable products group in which the index rose from 65.2 to 67.4. In the animals and their products group the index advanced from 65.5 to 66.6, a gain of a little more than a point. Similarly fibres, textiles and textile products rose from 73.7 to 74.7. Gains or losses in the other sub-indexes were not large.

*Retail Prices.*—The total index number of retail prices, rents, and costs of services declined from 78.7 in May to 78.4 in June. The food index fell off a full point whereas the clothing index rose from 69.9 to 70.1. Fuel prices were slightly lower.

*Physical Volume of Business.*—The index of the physical volume of business dropped to 95.8 in June. It will be recalled that there was a sharp rise in this index in May when it advanced to 99.6, seven points above that for April, and almost equal to the level of production in the base year 1926.

The index of industrial production declined to 95.2. Mineral production fell from 146.3 to 127. The index of manufacturing fell from 100.2 in May to 88.9 in June. The index of food production rose from 85.1 to 88.9. There was a substantial increase in output of sugar, and increased exports of cheese and canned salmon, whereas flour production remained at about the same level as in May. Among other sub-indexes production of boots and shoes was higher and imports of wool and rubber advanced but cotton imports were lower. Tobacco released for manufacturing was larger in amount than in the preceding month. Exports of planks and boards advanced. Automobile, newsprint, electric power, and steel production declined. Car loadings were slightly under those in May. Construction continued at a low level. In this connection it may be worth noting that the index of the cost of construction was 84.1 in May and has varied only about three points during the past twelve months.

*Agricultural Products.*—Wholesale prices of Canadian farm products advanced from 56.9 in May to 59.3 in June. The index of field products advanced from 51.1 to 55.5 but that of animal products receded from 66.5 to 65.6. The total index was largely influenced by higher prices for wheat and coarse grains which overshadowed the lower prices paid for all livestock except hogs. Prices of eggs were somewhat stronger and prices of butter advanced slightly. In the case of wool, lower values were realized. Dry weather has affected crops, dairy and livestock production in many areas with consequent restriction of supply and strengthening of prices in grains and dairy produce whereas in the case of livestock, except hogs, the result recently has been heavier shipments and lower prices. In this connection the livestock market report published by the Livestock Branch shows that for the 29 weeks ended July 19th, sales of cattle at public yards were 327,926 head in 1934 as compared with 288,214 in the same period of 1933. In the case of calves sales in 1934 have been 205,390 head as against 176,752 in 1933. Sales of sheep have been lower, amounting to 135,437 in the first 29 weeks of 1934 compared with 142,049 head in corresponding weeks of 1933. Total hog gradings in the same period were 1,761,972 and 1,828,006 respectively. The index of agricultural marketings was 97.2 in June as compared with 130.6 in May. Grain marketings were 99.6 as against 140.1 in May. Marketings of wheat were lower but shipments of coarse grains were higher than in the previous month. The index of livestock marketings was 86.7 as compared with 87.8 in May.

## ANNUAL AND MONTHLY INDEX NUMBERS OF PRICES AND PRODUCTION COMPUTED BY DOMINION BUREAU OF STATISTICS

| Year | Wholesale Prices 1926 = 100 | | | | Retail prices and cost of services (5) | Production (6) 1926 = 100 | | | |
|---|---|---|---|---|---|---|---|---|---|
| | All commodities (1) | Farm products (2) | Field products (3) | Animal products (4) | | Physical volume of business | Industrial production | Agricultural marketings | Cold Storage holdings |
| 1913 | 64.0 | 62.6 | 56.4 | 77.0 | 65.4 | | | | |
| 1914 | 65.5 | 69.2 | 64.9 | 79.0 | 66.0 | | | | |
| 1915 | 70.4 | 77.7 | 76.9 | 79.2 | 67.3 | | | | |
| 1916 | 84.3 | 89.7 | 88.4 | 92.3 | 72.5 | | | | |
| 1917 | 114.3 | 130.0 | 134.3 | 119.6 | 85.6 | | | | |
| 1918 | 127.4 | 132.9 | 132.0 | 134.7 | 97.4 | | | | |
| 1919 | 134.0 | 145.5 | 142.4 | 152.5 | 107.2 | 71.3 | 65.5 | 48.1 | 47.1 |
| 1920 | 155.9 | 161.6 | 166.5 | 149.9 | 124.2 | 75.0 | 69.9 | 52.6 | 94.2 |
| 1921 | 110.0 | 102.8 | 100.3 | 108.5 | 109.2 | 66.5 | 60.4 | 65.2 | 86.4 |
| 1922 | 97.3 | 86.7 | 81.3 | 99.1 | 100.0 | 79.1 | 76.9 | 82.6 | 82.8 |
| 1923 | 98.0 | 79.8 | 73.3 | 95.1 | 100.0 | 85.5 | 83.8 | 91.4 | 87.6 |
| 1924 | 99.4 | 87.0 | 82.6 | 97.2 | 98.0 | 84.6 | 82.4 | 102.5 | 114.9 |
| 1925 | 102.6 | 100.4 | 98.1 | 105.7 | 99.3 | 90.9 | 89.7 | 97.2 | 108.6 |
| 1926 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.9 | 100.0 |
| 1927 | 97.7 | 102.1 | 99.9 | 105.7 | 98.4 | 106.1 | 105.6 | 103.6 | 110.0 |
| 1928 | 96.4 | 100.7 | 92.6 | 114.3 | 98.9 | 117.3 | 117.8 | 146.7 | 112.8 |
| 1929 | 95.6 | 100.8 | 93.8 | 112.5 | 99.9 | 125.5 | 127.4 | 101.1 | 109.6 |
| 1930 | 86.6 | 82.3 | 70.0 | 102.9 | 99.2 | 109.5 | 108.0 | 103.0 | 128.4 |
| 1931 | 72.2 | 56.3 | 43.6 | 77.6 | 89.6 | 93.5 | 90.4 | 99.0 | 125.7 |
| 1932 | 66.7 | 48.4 | 41.1 | 60.7 | 81.4 | 78.7 | 74.0 | 114.3 | 120.1 |
| 1933 | 67.1 | 51.0 | 45.8 | 59.6 | 77.7 | 79.7 | 76.8 | 105.1 | 115.4 |
| 1933 | | | | | | | | | |
| Jan. | 63.9 | 43.6 | 35.1 | 57.9 | 79.1 | 68.1 | 62.2 | 56.1 | 112.0 |
| Feb. | 63.6 | 43.0 | 36.0 | 54.7 | 78.4 | 67.0 | 60.0 | 76.5 | 127.6 |
| Mar. | 64.4 | 44.7 | 38.0 | 56.0 | 77.8 | 68.4 | 62.5 | 129.0 | 135.8 |
| April | 65.4 | 46.8 | 41.1 | 56.4 | 78.0 | 69.8 | 65.1 | 104.1 | 112.7 |
| May | 66.9 | 51.2 | 46.9 | 58.4 | 77.0 | 76.4 | 72.7 | 95.4 | 110.4 |
| June | 67.6 | 52.6 | 49.4 | 57.9 | 77.0 | 82.2 | 79.8 | 221.9 | 119.9 |
| July | 70.5 | 60.1 | 60.8 | 59.0 | 77.2 | 84.1 | 82.6 | 221.9 | 119.9 |
| Aug. | 69.4 | 57.0 | 54.9 | 60.5 | 78.6 | 89.8 | 89.5 | 197.2 | 114.2 |
| Sept. | 68.9 | 54.7 | 49.5 | 63.4 | 78.8 | 90.8 | 90.2 | 101.1 | 115.7 |
| Oct. | 67.9 | 51.4 | 44.6 | 62.8 | 77.9 | 88.2 | 87.4 | 70.5 | 112.7 |
| Nov. | 68.7 | 53.8 | 46.7 | 65.8 | 78.1 | 85.5 | 83.9 | 41.8 | 111.1 |
| Dec. | 69.0 | 53.3 | 45.3 | 66.6 | 78.4 | 86.2 | 85.1 | 30.7 | 107.6 |
| 1934 | | | | | | | | | |
| Jan. | 70.6 | 55.3 | 47.9 | 67.8 | 78.7 | 86.8 | 84.5 | 48.2 | 108.1 |
| Feb. | 72.1 | 58.0 | 49.3 | 72.5 | 79.2 | 86.4 | 84.0 | 67.1 | 98.6 |
| Mar. | 72.0 | 56.5 | 49.5 | 68.3 | 80.2 | 93.1 | 92.0 | 63.8 | 97.0 |
| Apr. | 71.1 | 55.4 | 48.7 | 66.6 | 79.6 | 92.6 | 91.4 | 56.9 | 94.5 |
| May | 71.1 | 56.9 | 51.1 | 66.5 | 78.7 | 99.6 | 99.4 | 130.6 | 102.6 |
| June | 72.1 | 59.3 | 55.5 | 65.6 | 78.4 | 95.8 | 95.2 | 97.2 | 116.3 |

1. See Prices and Price Indexes 1913-1928, pp. 19-21, 270-289 and 1913-1931, p. 15.

2. Wholesale prices of Canadian products of farm origin only. See Prices and Price Indexes 1913-1931, p. 33, and Monthly Mimeographs 1933 and 1934.

3. Wholesale prices of grains, fruits and vegetables.

4. Wholesale prices of Animals and Animal Products.

5. Including foods, rents, fuel, clothing and sundries, See Prices and Price Indexes 1913-1928, pp. 181-185, 290-293. 1926=100.

Prices and Price Indexes 1913-1931, p. 122, and Monthly Mimeographs 1933-1934.

6. Monthly Review of Business Statistics, p. 8, and Monthly Indexes of the Physical volume of business in Canada, supplement to the Monthly Review of Business Statistics, November, 1932.

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The index of cold storage holdings rose from 102.6 to 116.3 in June and continued its rise in July when the index was 126.1. Holdings of eggs were higher. Butter stocks were above those in June but not as large as is normally the case. Supplies of cheese showed little change while those of pork, lard and veal declined.

While indexes of production are lower than in the previous month, prices have advanced slightly and the situation would seem to be somewhat better than might have been anticipated at this season of the year.

*Farm Prices in United States.*—The index of prices paid to farmers for farm products in United States was 77 as compared with 74 in May. This index is based upon the 5-year average 1909-1914. The ratio of prices received by farmers to those paid for goods purchased was 63 in June and 61 in May, in June, 1933, it was 62. Comparable indexes have not been constructed for Canadian farm products.

*Prices in Great Britain.*—The monthly index number of prices of agricultural produce (corresponding months 1911–13 = 100) was 111 in April and 112 in May Indexes of individual commodities in May were as follows: wheat, 59; barley, 98; fat cattle, 150; bacon pigs, 150; milk, 162; butter, 85; cheese, 123; wool, 89; poultry, 129; potatoes, 90. It is interesting to note that, according to the Journal of Agriculture "Wheat, at 4s. 8d. per cwt., was 4 d. dearer during May, and the index rose 2 points to 59. If allowance is made for the "deficiency payment" under the Wheat Act, 1932, the index would be increased to approximately 126, the effect of which would be to raise the general index for agricultural produce from 112 to 117. The average for barley further decreased by 5d. to 7s. 6d. per cwt., and the index by 5 points to 98. The index for oats also declined from 84 to 81 but, in this instance, the reduction was due to an increase which occurred in the base period, the average for May, 1934, at 6s. per cwt. being 1d. above that for April."

# LA SITUATION ÉCONOMIQUE

PRÉPARÉ PAR LA DIVISION DE L'ÉCONOMIE AGRICOLE, MINISTÈRE DE L'AGRICULTURE
OTTAWA, PRINCIPALEMENT AVEC LES DONNÉES COMPILÉES AU
BUREAU FÉDÉRAL DE LA STATISTIQUE

Une hausse des prix du gros au Canada s'est produite en juin; l'indice qui était à 71.1 en mai est monté à 72.1. Une hausse assez considérable a été enregistrée dans les cours des produits végétaux, l'indice passant de 65.2 à 67.4. Dans le groupe des animaux et de leurs produits, l'indice a passé de 65.5 à 66.6, une augmentation d'un peu plus d'un point. De même, les produits textiles se sont élevés de 73.7 à 74.7. Les gains ou les pertes dans les autres sous-indices n'ont pas été aussi considérables.

*Prix de détail.*—Le chiffre-indice des prix de détail, des loyers et des frais de services, qui était à 78.7 en mai est tombé à 78.4 en juin. L'indice des aliments a baissé d'un point entier tandis que l'indice des vêtements s'élevait de 69.9 à 70.1. Les prix du combustible ont légèrement baissé.

*Volume physique des affaires.*—L'indice du volume physique des affaires est descendu à 95.8 en juin. On se rappelle que cet indice était monté brusquement en mai, atteignant jusqu'à 99.6, sept points de plus que celui d'avril, et qui était presque égal au niveau de production de l'année de base, 1926.

L'indice de la production industrielle est tombé à 95.2; la production minérale qui était de 146.3 est descendue à 127. L'indice de l'industrie manufacturière qui était à 100.2 en mai est tombé à 88.9 en juin, tandis que l'indice de la production des aliments passait de 85.1 à 88.9. Il y a eu une augmentation considérable dans la production de sucre; les exportations de fromage et de saumon en conserves ont augmenté tandis que la production de la farine restait à peu près au même niveau qu'en mai. Parmi les autres sous-indices, la production de chaussures et de souliers était plus élevée, les importations de laine et de caoutchouc ont augmenté tandis que celles de coton diminuaient. Il s'est envoyé aux manufactures une quantité de tabac plus considérable que le mois précédent. L'exportation de madriers et de planches a augmenté. La production d'automobiles, de papier à journal, d'énergie électrique et d'acier a baissé. Les chargements de wagon étaient légèrement inférieurs à ceux de mai. La construction est restée à un faible niveau. Il est à noter sous ce rapport que l'indice des prix de revient était 84.1 en mai et qu'il n'a varié que de trois points en ces douze derniers mois.

*Produits agricoles.*—Les prix du gros des produits agricoles canadiens qui étaient à 56.9 en mai ont passé à 59.3 en juin. L'indice des produits des champs est passé de 51.1 à 55.5 mais celui des produits animaux descendait de 66.5 à 65.6. L'indice total a été largement influencé par les hauts prix payés pour le blé et les autres grains, laissant dans l'ombre les prix inférieurs payés pour tous les bestiaux à l'exception des porcs. Les prix des œufs ont un peu remonté de même que les prix du beurre. Quant à la laine, la valeur a diminué. Dans beaucoup de districts la sécheresse a affecté les récoltes, la production laitière et l'élevage, si bien que les approvisionnements ont diminué et que les prix ont remonté en ce qui concerne les grains et les produits laitiers; pour ce qui est des bestiaux, à l'exception des porcs, les expéditions ont augmenté, accompagnées d'une baisse de prix. A ce sujet, le rapport du commerce des bestiaux, publié par la Division de l'Industrie Animale, fait voir que pendant les 29 semaines finissant le 19 juillet, il s'est vendu aux parcs à bestiaux 327,926 animaux en 1934 contre 288,214 pendant la même période en 1933. En ce qui concerne les veaux, les ventes ont été de 205,390 têtes en 1934 contre 176,752 en 1933. Les ventes de moutons ont été plus faibles, se montant à 135,437 pendant les premières 29 semaines de 1934 contre 142,049 têtes pendant les semaines correspondantes de 1933.

Le classement total des porcs pendant la même période a été de 1,761,972 et 1,828,006 respectivement. L'indice des ventes agricoles a été de 97.2 en juin contre 130.6 en mai. Les ventes de grain ont été de 99.6 contre 140.1 en mai. Les ventes de blé ont diminué mais les expéditions d'autres grains ont été plus fortes que le mois précédent. L'indice des ventes de bestiaux était de 86.7 contre 87.8 en mai.

L'indice des produits conservés au froid s'est élevé de 102.6 à 116.3 en juin et a continué sa marche ascentionnelle en juillet pour atteindre le chiffre de 126.1. La quantité d'œufs conservés était plus forte. Les stocks de beurre étaient supérieurs à ceux de juin mais pas aussi considérables que la normale. Les stocks de fromage n'ont que peu changé tandis que ceux de lard, de saindoux et de veau ont diminué.

Les indices de production sont plus faibles que le mois précédent mais les prix ont légèrement monté et la situation paraît être un peu meilleure qu'il n'était à prévoir à cette saison de l'année.

*Prix des produits agricoles aux Etats-Unis.*—L'indice des prix payés aux cultivateurs pour les produits agricoles aux Etats-Unis était de 77 contre 74 en mai. Cet indice est basé sur la moyenne de 5 ans 1909-1914. Le rapport entre les prix reçus par les cultivateurs et les prix payés pour les marchandises achetées était de 63 en juin et 61 en mai; en juin 1933 il était de 62. Il n'a pas été préparé d'indices comparables pour les produits de ferme canadiens.

*Prix en Grande-Bretagne.*—Le chiffre-indice mensuel des prix des produits agricoles (mois correspondants 1911-13 = 100) était de 111 en avril et de 112 en mai. En mai les indices des différents produits étaient les suivants:—blé, 59; orge, 98; bœufs gras. 150; porcs à bacon, 150; lait, 162; beurre, 85; fromage, 123; laine, 89; volailles, 129; pommes de terre, 90. Une constatation intéressante, relevée dans le Journal of Agriculture, "c'est que le blé à 4s. 8d. le quintal, était de 4d. plus cher en mai et l'indice s'est élevé de 2 points à 59. Si l'on tient compte du paiement du déficit autorisé par la loi du blé 1932, l'indice serait porté à environ 126, ce qui aurait pour effet de faire monter l'indice général des produits agricoles de 112 à 117. La moyenne pour l'orge a encore diminué, de 5d. à 7s. 6d. le quintal et l'indice de 5 points à 98. L'indice pour l'avoine a baissé également de 84 à 81, mais dans ce cas la réduction est due à l'augmentation qui s'est produite dans la période de base, la moyenne pour mai 1934 à 6s. le quintal étant de 1d. supérieure à celle d'avril."

## CURRENT PUBLICATIONS

**Rasmussen**, M.P. Some Facts Concerning the Marketing of Eastern Grapes, Part 1. Competition, Distribution, and Wholesale Marketing, Part II. Retail Distribution and Consumer Demand. Cornell Extension Bulletins 275 and 276; New York State College of Agriculture, Ithaca, N.Y.

The purpose of these two bulletins was to obtain all information possible on the marketing of Eastern grapes in order to provide a basis upon which Eastern grape producers might make plans for the future constructive development of the industry.

It was found that the principal fresh fruits which compete seasonally with grapes are apples, oranges, grapefruit, pears, peaches and bananas. California grapes are available for approximately seven months of the year while eastern grapes from any producing area have an extremely short season. This is a serious disadvantage in merchandising, since consumers are often uninformed concerning the actual length of the eastern grape season. Relatively high freight rates (considering distance hauled) probably restrict the distribution of eastern grapes compared with the California or vinefera type. The establishment of "commodity rates" and greater use of motor truck transportation might increase the area of distribution.

Part II comprises the results of a study of retail distribution of, and consumer demand for eastern grapes in five cities. In each city areas were selected that would be representative of the total city population, nationality of population, and the income group dominant in each area. The conclusions arrived at after studying retail outlets and interviewing consumers were as follows: Under normal circumstances, it is improbable that price acts as a deterrent to sales to any appreciable extent, since the quantity of eastern grapes usually purchased at one time is relatively small, namely, from 3 to 6 pounds, and purchases of eastern grapes for jelly or juice were generally largest in families with low incomes. The most serious criticism of eastern grapes was that they were "slack packed." If the demand for eastern grapes is to be increased, it seems desirable that steps be taken to insure full weight and pack. If table demand is to be increased, probably the grade and pack of grapes in small packages will have to be standardized to a greater degree than at present. This can probably be accomplished through central packing houses.

It is suggested that an educational campaign be conducted to acquaint the public of the health value of grape juice and the methods of making grape jelly. Attractive window displays and intensive advertising directed at the housewife should do much to stimulate demand for this product.

Recent developments in food merchandising lead consumers to expect to purchase all food supplies in one food store, which is frequently a combination grocery, fruit, vegetable and meat store. Joint efforts on the part of grape-growers' associations to induce a more active and sympathetic interest in the sale of eastern grapes on the part of chain and independent grocers might result in a considerable increase in demand for such grapes.

**Shoemaker**, J. S. Small-Fruit Culture. Blakiston's Son & Co., Philadelphia, 1934. Price $3.50.

This treatise on small-fruit culture covers the field in a comprehensive manner, but no attempt is made to deal exhaustively with these fruits and in a book of this size-four hundred odd pages—it would be out of the question. The author does, however, bring together a great deal of material that is of decided value to the student, the teacher and practical fruit grower. The following quotation from the author's preface sums up the main content of the book: "Much helpful information on small-fruit culture, the result of experiments, research and experience under a variety of practical conditions, is presented herein. This material has not yet been used to the extent it deserves, largely because it has never been brought together in conveniently usable form. The discussion in the text is based on information derived from: the extensive but scattered literature; suggestions (hitherto unpublished) from specialists at various institutions; growers' experiences; and, the author's own work with small fruits."

The book is divided into six parts dealing respectively with the Grape, Strawberry, Bramble Fruits, Currant and Gooseberry, Blueberry and Cranberry. Each part is complete in itself and follows the same general plan, main topics being: The Industry, Regions and Districts; Development and Characteristics of Varieties; Cultural Details including Propagation, Location and Site, Planting, Tillage, Fertilizers, Irrigation, etc.; Fruit Bud Formation; Harvesting and Marketing; Insect Pests and Diseases.

The bibliography of three hundred and eighty-nine references is probably one of the best on small fruits. The whole book is in keeping with the more modern type of text books on fruit growing.—W. J. Strong.

**I. A. R. I. 75.**

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